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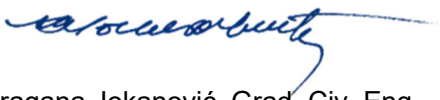
2/2.1.6.1 TITLE PAGE

	2/2.6.1 DESIGN OF SUPERSTRUCTURE FOR BRIDGE STRUCTURES LONGER THAN 40M SECTION NOVI SAD – RUMENKA ENTRY
Investor:	„Serbian Railway Infrastructure" JSC Nemanjina 6/IV, Belgrade
Employer:	Consortium: China Railway International Corporation Ltd. (CRIC) China Communication Construction Company Ltd. (CCCC)
Object:	Belgrade – Subotica – State Border (Kelebija) Railway Line, Section Novi Sad – Subotica – State Border (Kelebija), in Novi Sad, Kisač, Stepanovićevo, Zmajevo, Vrbas, Lovćenac, Mali Iđoš, Bačka Topola, Žednik, Naumovićevo and Subotica, C.M. Novi Sad I, C.M. Novi Sad IV, C.M. Kisač, C.M. Rumenka, C.M. Stepanovićevo, C.M. Čenej, C.M. Bačko Dobro Polje, C.M. Vrbas - ATAR, C.M. Vrbas - grad, C.M. Zmajevo, C.M. Kucura, C.M. Lovćenac, C.M. Mali Iđoš, C.M. Feketić, C.M. Bačka Topola, C.M. Bačka Topola - Grad, C.M. Mali Beograd, C.M. Bikovo, C.M. Donji Grad, C.M. Žednik, C.M. Novi Grad, C.M. Palić, C.M. Stari Grad, on cadastral parcels according to the list attached to Main Notebook
Type of technical documentation:	**DFC –** Design for construction
Name and designation part of project:	**2/2.6.1 DESIGN OF SUPERSTRUCTURE FOR BRIDGE STRUCTURES LONGER THAN 40M SECTION NOVI SAD – RUMENKA ENTRY**
For construction / execution of works:	New construction
Designer:	Saobraćajni institut CIP, d.o.o. Nemanjina 6/IV,Beograd 351-02-03602/2020-09
Representative of designer:	Managing Director: Milutin Ignjatović, Grad. Eng.
Signature:	
Responsible designer:	Dragana Jokanović, Grad. Civ. Eng. License number: 315 1404 03
Signature:	Dragana Jokanović Digitally signed by Dragana Jokanović Date: 2022.01.12 16:02:30 +01'00'
Number of designation part of project:	2020-250-SAO-2/2.6.1
Place and date:	Belgrade, December 2021.

2/2-6.1.2. TABLE OD CONTENTS

DESIGN OF PERMANENT WAY ON THE BRIDGE STRUCTURES LONGER THAN 40 M

Novi Sad - Rumenka Entry section

2/2-6.1.1.	Title page
2/2-6.1.2.	Table of Contents
2/2-6.1.3.	Decision on appointment of the responsible designer
2/2-6.1.4.	Responsible designer's statement
2/2-6.1.5.	Textual documentation
2/2-6.1.5.1.	Technical description
2/2-6.1.6.	Numerical documentation
2/2-6.1.6.0.	Quantities measurement notes
2/2-6.1.6.1.	Investment value of permanent way for the bridge structure at km 81+650,20 R.T.(81+644.83 L.T.)
2/2-6.1.6.2.	Investment value of permanent way for the bridge structure at km 0+751.01 R.T. (0+796,33 L.T.)
2/2-6.1.6.3.	Investment value of permanent way for the bridge structure at km 78+401.27 R.T. (78+377,03 L.T.)
2/2-6.1.6.4.	Investment value of permanent way for the bridge structure at km 82+152,69 R.T. (82+153.77 L.T.)
2/2-6.1.6.5.	Investment value of permanent way for the bridge structure at KM 76+615.57R.T. (76+601.02 L.T.) и на км 77+814.32 R.T. (77+807.99 L.T.), and galleries at KM 81+283.13 R.T. (81+284.54 L.T.) and grand summary
2/2-6.1.6.6.	Calculations interaction vehicle/ track/bridge
2/2-6.1.6.6.1	Calculations of vehicle/ track/bridge interaction for bridge at KM 76+615.57 R.T. (76+601.02 L.T.)
2/2-6.1.6.6.2	Calculations of vehicle/ track/bridge interaction for bridge at KM 77+814.32 R.T. (77+807.99 L.T.)
2/2-6.1.6.6.3	Calculations of vehicle/ track/bridge interaction for bridge at KM 81+650.20 R.T. (81+644.83 L.T.)
2/2-6.1.6.6.4	Calculations of vehicle/ track/bridge interaction for bridge at KM 0+751.01 R.T. (0+796,33 L.T.)
2/2-6.1.7.	Graphic documentation

2/2-6.1.7.1.1	Longitudinal profile of the bridge at km 76+615.57R.T. (76+601.02 L.T.)
2/2-6.1.7.1.2	Cross section of the bridge at km 76+615.57 R.T. (76+601.02 L.T.)
2/2-6.1.7.1.3	Position of elasthomeric pads for bridge at km 76+615.57 R.T. (76+601.02 L.T.)
2/2-6.1.7.2.1	Longitudinal profile of the bridge at km 77+814.32 R.T. (77+807.99 L.T.)
2/2-6.1.7.2.2	Cross section of the bridge at km 77+814.32 R.T. (77+807.99 L.T.)
2/2-6.1.7.3.1	Longitudinal profile of the bridge at km 81+650.20 R.T. (81+644.83 L.T.)
2/2-6.1.7.3.2	Cross section of the bridge at km 81+650.20 R.T. (81+644.83 L.T.)
2/2-6.1.7.4.1	Longitudinal profile of the bridge at km 0+751.01 R.T. (0+796,33 L.T.)
2/2-6.1.7.4.2	Cross section of the bridge at km 0+751.01 R.T. (0+796,33L.T.)
2/2-6.1.7.5.1	Longitudinal profile of the bridge at km 78+401.27 R.T. (78+377,03 L.T.)
2/2-6.1.7.5.2	Cross section of the bridge at km 78+401.27 R.T. (78+377,03 L.T.)
2/2-6.1.7.6.1	Longitudinal profile of the bridge at km 81+283.13 R.T. (81+284.54L.T.)
2/2-6.1.7.6.2	Cross section of the bridge at km 81+283.13 R.T. (81+284.54 L.T.)
2/2-6.1.7.7.1	Longitudinal profile of the bridge at km 82+152,69 R.T. (82+153.77 L.T.)
2/2-6.1.7.7.2	Cross section of the bridge at km 82+152,69 R.T. (82+153.77L.T.)
2/2-6.1.7.8	Layout of tracks with guard rails types 60E1 on bridges
2/2-6.1.7.9	Layout of tracks with guard rails types 49E1 on bridges

2/2.6.1.3 РЕШЕЊЕ О ОДРЕЂИВАЊУ ОДГОВОРНОГ ПРОЈЕКТАНТА

На основу Члана 128, Закона о планирању и изградњи ("Службени гласник РС", бр. 72/09, 81/09-исправка, 64/10- одлука УС, 24/11, 121/12, 42/13-одлука УС, 50/13-одлука УС, 98/13-одлука УС, 132/14, 145/14, 83/2018, 31/2019, 37/2019 - др.закон, 9/20 и 52/21) и одредби Правилника о садржини, начину и поступку израде и начину вршења контроле техничке документације према класи и намени објеката ("Службени гласник РС", бр. 73/2019) као:

О Д Г О В О Р Н И П Р О Ј Е К Т А Н Т

за израду **ПРОЈЕКТА ТРАСЕ ПРУГЕ И СТАНИЦА - ДОЊИ И ГОРЊИ СТРОЈ 2/2.6.1 Пројекат горњег строја за мостовске конструкције дужине преко 40м, деоница Нови Сад – Руменка (излаз)**, који је део ПЗИ - Пројекта за извођење за изградњу пруге Београд - Суботица државна граница (Келебија), **ДЕОНИЦА ПРУГЕ НОВИ САД - СУБОТИЦА - ДРЖАВНА ГРАНИЦА (КЕЛЕБИЈА)**, у Новом Саду, Кисачу, Степановићеву, Змајеву, Врбасу, Ловћенцу, Малом Иђошу, Бачкој Тополи, Жеднику, Наумовићеву и Суботици, К.О. Нови Сад I, К.О. Нови Сад IV, К.О. Кисач, К.О. Руменка, К.О. Степановићево, К.О. Ченеј, К.О. Бачко Добро Поље, К.О. Врбас, К.О. Врбас - град, К.О. Змајево, К.О. Куцура, К.О. Ловћенац, К.О. Мали Иђош, К.О. Фекетић, К.О. Бачка Топола, К.О. Бачка Топола - Град, К.О. Мали Београд, К.О. Биково, К.О. Доњи Град, К.О. Жедник, К.О. Нови Град, К.О. Палић, К.О. Стари Град, на катастарским парцелама према списку приложеном у Главној свесци, одређује се:

Драгана Јокановић, дипл. грађ. инж. _____ 315 1404 03

Пројектант:	САОБРАЋАЈНИ ИНСТИТУТ ЦИП д.о.о., Београд Немањина 6/IV
Одговорно лице/заступник:	Генерални директор: Милутин Игњатовић, дипл. инж.
	Потпис:
Број техничке документације:	2020-250-САО-2/2.6.1
Место и датум:	Београд, децембар 2021.год.

2/2.6.1.4 ИЗЈАВА ОДГОВОРНОГ ПРОЈЕКТАНТА

Одговорни пројектант **ПРОЈЕКТА ТРАСЕ ПРУГЕ И СТАНИЦА-ДОЊИ И ГОРЊИ СТРОЈ-2/2.6.1 Пројекат горњег строја за мостовске конструкције дужине преко 40м – деоница Нови Сад – Руменка (излаз)**, који је део ПЗИ - Пројекта за извођење за изградњу пруге Београд - Суботица државна граница (Келебија), **ДЕОНИЦА ПРУГЕ НОВИ САД - СУБОТИЦА - ДРЖАВНА ГРАНИЦА (КЕЛЕБИЈА)**, у Новом Саду, Кисачу, Степановићеву, Змајеву, Врбасу, Ловћенцу, Малом Иђошу, Бачкој Тополи, Жеднику, Наумовићеву и Суботици, К.О. Нови Сад I, К.О. Нови Сад IV, К.О. Кисач, К.О. Руменка, К.О. Степановићево, К.О. Ченеј, К.О. Бачко Добро Поље, К.О. Врбас, К.О. Врбас - град, К.О. Змајево, К.О. Куцура, К.О. Ловћенац, К.О. Мали Иђош, К.О. Фекетић, К.О. Бачка Топола, К.О. Бачка Топола - Град, К.О. Мали Београд, К.О. Биково, К.О. Доњи Град, К.О. Жедник, К.О. Нови Град, К.О. Палић, К.О. Стари Град, на катастарским парцелама према списку приложеном у Главној свесци:

Драгана Јокановић, дипл. грађ. инж.

И З Ј А В Љ У Ј Е М

1. да је пројекат у свему у складу са издатим Локацијским условима:

-бр. ROP-MSGI-7141-LOC-1/2020, Заводни број: 350-02-00109/2020-14 од 08.05.2020,

-бр. ROP-MSGI-931-LOCA-3/2020, Заводни број: 350-02-00192/2020-14 од 29.05.2020;

-бр. ROP-MSGI-28188-LOCAH-6/2021, Заводни број: 350-02-01883/2021-07 од 30.09.2021. год.

2. да је пројекат у свему у складу са пројектом за грађевинску дозволу и издатом грађевинском дозволом:

-бр. ROP-MSGI-27315-CPI-2/2021, Заводни број: 351-02-03590/2021-07 од 26.10.2021.год.

3. да је пројекат израђен у складу са Законом о планирању и изградњи, прописима, стандардима и нормативима из области изградње објеката и правилима струке;

4. да је пројекат у свему у складу са начинима за обезбеђење испуњења основних захтева за објекат прописаних елаборатима и студијама.

Одговорни пројектант:	Драгана Јокановић, дипл. грађ. инж.
Број лиценце:	315 1404 03
	Потпис:
Број техничке документације:	2020-250-САО-2/2.6.1
Место и датум:	Београд, децембар 2021.год.

2/2-6.1.5. TEXTUAL DOCUMENTATION

2/2-6.1.5.1 TECHNICAL DESCRIPTION

2.2.6.1.5.1. Design of permanent way for bridge structures longer than 40 m Novi Sad - Rumenka Exit section

Technical description

Based on the calculations of vehicle/track/bridge interaction made by CRDC responsible designer for bridge structures, the Design for construction of permanent way for bridge structures longer than 40 m was completed as a part of the Building permit design for modernization (reconstruction and new construction) of the Belgrade – Subotica - State border (Kelebija) railway line, Novi Sad - Subotica - State border (Kelebija) section.

The calculations of vehicle/track/bridge interaction taken from the Designs of bridges are included in the Numerical documentation of this Volume.

The bridge structures shall be provided with elastomer mats under ballast and corresponding cost estimate is included in the Design of bridge structures.

This Design includes permanent way on the bridge structures and along 10.4 m length before and behind the bridge structures (from the beginning to the end of guard rail) and cost estimates for transition sleepers and elastomeric rail pads.

This design also includes descriptions of the bridges at km 76+615.57 R.T. and km 77+814.32 R.T. and the gallery at km 81+283.13 R.T. shorter than 40 m, and cost estimates for permanent way sections on them (specific for bridge structures) which were not estimated in the Design of track alignment and stations – substructure and permanent way – Novi Sad station, Volume 2/2-1.1.

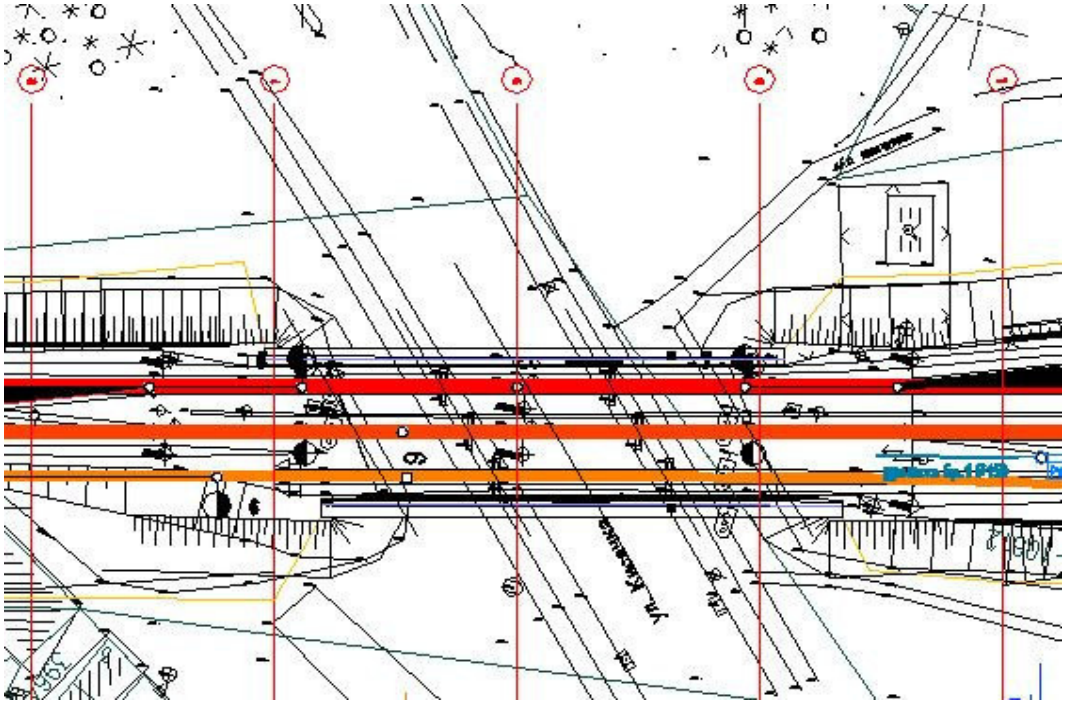
Due to different heights of railway sleepers (h= 210 mm) and flat concrete sleepers on bridges (h=193 mm), transition concrete sleepers (h=200 mm) will be placed along 15 m length between concrete track sleepers and concrete sleepers on bridges to enable gradual change of height. Type of fastening system on transition concrete sleepers is same as fastening system on railway sleepers and therefore it was not estimated in this design.

Concrete sleepers with elastomeric pads shall be placed in transition zones before and behind the bridge for achieving linear change of the base rigidity in accordance with EN 16730 in order to reduce maintenance costs. The transition zone length was calculated based on 0.5 s of train speed.

Nominal track gauge on straight sections and in curves is 1435 mm, allowable deviations from the designed track gauge values in accordance with SRPS EN13231-1
Inclination of the axis of symmetry of laid rails towards track centerline in cross section is 40:1
Rail fastening system in accordance with SRPS EN 13481:2013
Ballast made of class 1 crushed stone in accordance with SRPS EN 13450
Thickness of ballast under the sleepers before and behind the bridge is 30 cm minimum
Thickness of ballast under the sleepers on the bridge structures is 35 cm minimum
The rail length proposed in the design is 50 m and 25 m for guard rails. Longer running rails can also be used. The maximum guard rail length is 30 m. The rails shall be welded by electric resistance welding process, but aluminothermic welding process can also be used (final welding of rails in track and welding of expansion joints). The Design specifies that electric resistance welding process shall be used to weld rails into 300 m sections.

1.Technical description of the bridge at km 76+615.57 R.T. (76+601.02 L.T.), 40.60 m long

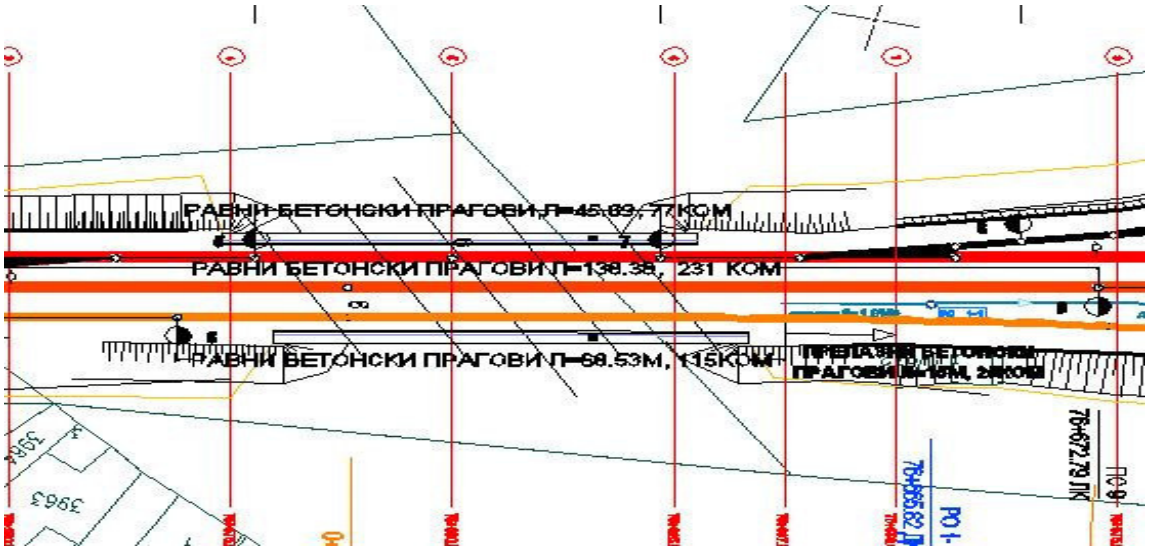
The bridge structure, 40.60 m long at km 76+615.57 over Kisačka Street is located before Novi Sad passenger station at Belgrade end. Structural system of the bridge is continuous girder over 11.60 m + 17.40 m + 11.60 m spans on crushed stone ballast.
The left and right tracks of the main railway line and the freight track run across the bridge. Speed on the bridge is 100 km/h. The bridge is designed in a straight line on the layout plan and the track reference level is designed without gradient. Center-to-center-distance between the left and right tracks of the main railway line is 4.75 m while center-to-center-distance between right track of the main railway line and the freight track is 4.88 m.



Permanent way on the bridge structures is designed according to newly designed permanent way on open line.
All three tracks are assembled of 60 E1 rails on 2.60 m long concrete sleepers on ballast made of class 1 crushed stone.

60E1 guard rails with elastic fastening system shall be laid on bridge structures and along 10.4 m length before and behind the bridge to serve as protection against harmful effects of train derailment.Considering the positions of switch No. 5 and switch No. 7, guard rails on the left track of the main railway line end at tip of switch No. 5 and at tip of switch No. 7.

Since switches are located just before and behind the bridge, flat concrete sleepers - for zone between the switch and the bridge, 2.60m long shall be placed from the end of switch No. 4 to the tip of switch No. 9 and on the freight track from the tip of switch No. 6 to the beginning of guard rails as shown in figure below in order to avoid the use of different sleeper types over relatively short distance on the right track of the main railway line. Transition concrete sleepers shall be placed on the freight track along 15 m length behind guard rails.



The bridge structure was treated in the Structural design, Volume 2/1.1.1 Design of underpass in Kisačka Street at km 76+601.02.

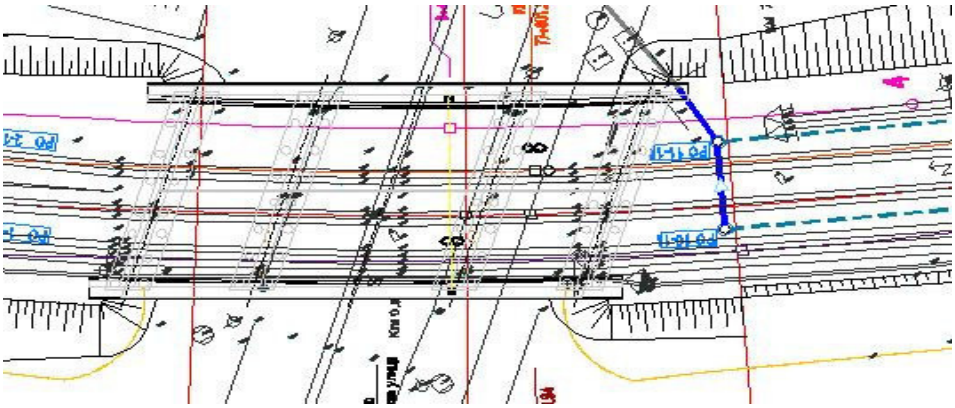
The investment value of permanent way was specified in the Design of track alignment and stations – substructure and permanent way – Novi Sad station, Volume 2/2-1.1. This design includes the investment value of procurement, transport and unloading of elastic rail pads under concrete sleepers, flat concrete sleepers - for zone between the switch and the bridge, 2.60m long and fastening system and transition concrete sleepers.

In order to increase the base elasticity and enable gradual change of rail deflection when ruling vehicle passes from the track on embankment to transition structure and from transition structure to bridge structure, elastomeric pads shall be placed under 2.60 m long concrete sleepers as follows: on the left track of the main railway line from tip of switch 5 to the beginning of the bridge and from the end of the bridge to tip of switch 7 under concrete sleepers on bridges; on the right track of the main railway line along 15 m length before and behind the bridge under concrete sleepers on bridges and flat concrete sleepers for the zone between the switch and the bridge; on the freight track along 17.15 m length before the bridge and 10.40 m behind the bridge under concrete sleepers on bridges and flat concrete sleepers for the zone between the switch and the bridge; and on the freight track along 4.60 m length under transition sleepers.

Since the bridge expansion length exceeds 40 m, the CRDC designer calculated the track-bridge interaction and it was taken from Volume No. 2/1.1.1 Design of underpass in Kisačka Street at km 76+601.02.

The calculation was made under assumption that maximum longitudinal resistance during elastic rail movement through elastic fastening system is 30 kN/m, which corresponds to 9 kN longitudinal resistance force. The calculation has shown that track is stable in horizontal plane and that compressive stress, tensile stress, maximum relative movements, absolute movements and horizontal movements due to turned ends of bridge superstructure under high train vertical load are within permitted limits.

2. Technical description of the bridge at km 77+814.32 R.T. (77+807.99 L.T.), 42.05 m long



The bridge structure, 42.05 m long crosses Partizanska Street at km 77+807.99. Structural system of the bridge is continuous girder over 11.60 m + 18.85 m + 11.60 m spans on crushed stone ballast. The left and right tracks of the main railway line and the left and right connecting tracks run across the bridge. Speed on the bridge is 80 km/h. The shorter sections of the tracks on the bridge lie in circular curve of 390 m radius while their longer sections lie in transition curve. Design gradient of the track reference level is 4.0‰.

The tracks of the main railway line are assembled of 60 E1 rails on 2.60 m long concrete sleepers on ballast made of class 1 crushed stone. The connecting tracks before and behind the bridge are assembled of 49 E1 rails. The calculation of the interaction has shown that values of additional stresses in 49 E1 rails would be exceeded if these rails were used on the bridge. For this reason 60 E1 rails on 2.60 m long concrete sleepers on ballast made of class 1 crushed stone are used for connecting tracks on the bridge and in the zones 50 m before and 50 m behind the bridge.

60E1 guard rails with elastic fastening system shall be laid on bridge structures and along 10.4 m length before and behind the bridge as protection against harmful effects of train derailment on the left and right tracks of the main railway line as well as on the left and right connecting tracks.

Transition concrete sleepers shall be placed on all four tracks along 15 m length before and behind guard rails.

The bridge structure was treated in Volume 2/1-1.2 Design of underpass in Partizanska Street at km 77+814.32 (77+807.90).

The investment value of permanent way was specified in the Design of track alignment and stations – substructure and permanent way – Novi Sad station, Volume 2/2-1.1. This design includes the investment value of procurement, transport and unloading of elastic rail pads under concrete sleepers in transition zones, and of transition sleepers.

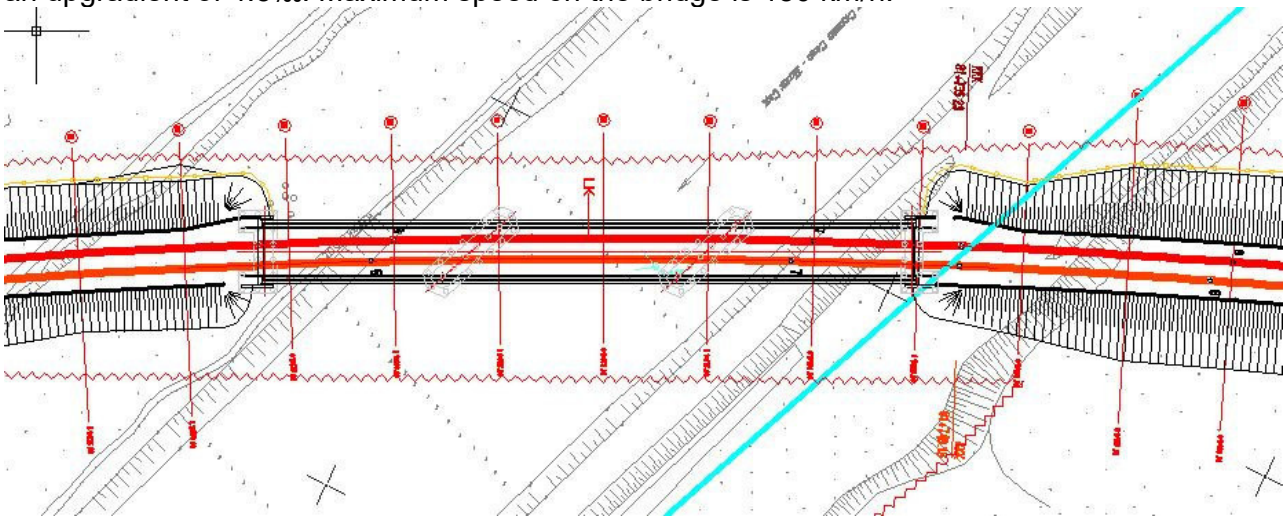
Elastomeric pads under 2.60 m long concrete track sleepers on bridges shall be placed along 10.4 m length before and behind bridge in order to increase the base elasticity and enable gradual change of rail deflection when ruling vehicle passes from the track on embankment to transition structure as well as from transition structure to bridge structure.

Since the bridge expansion length exceeds 40 m, the CRDC designer calculated the track-bridge interaction and it was taken from Volume No. 2/1-1.2 Design of underpass in Partizanska Street at km 77+814.32 (77+807.90).

The calculation was made under assumption that maximum longitudinal resistance during elastic rail movement through elastic fastening system is 30 kN/m, which corresponds to 9 kN longitudinal resistance force. The calculation has shown that track is stable in horizontal plane and that compressive stress, tensile stress, maximum relative movements, absolute movements and horizontal movements due to turned ends of bridge superstructure under high train vertical load are within permitted limits.

3. Technical description of the bridge at km 81+650.20 R.T. (81+644.83 L.T.), 154 m long

New double-track bridge is designed at km 81+650.20 over the Novi Sad - Savino Selo canal and it is a part of newly designed main railway line situated on the Novi Sad - Rumenka Exit section. The bridge structure is treated in Volume 2/1-1.6 Design of the bridge at km 81+650.20. Center-to-center distance between tracks is 4.75 m. The right track lies in horizontal curve of radius R=2000 m and the left track lies in horizontal curve of radius R=2004.75 m. The track has an upgradient of 4.5‰. Maximum speed on the bridge is 180 km/h.



Permanent way on the bridge structure is designed according to newly designed permanent way on open line. Both tracks are assembled of 60 E1 rails on 2.60 m long concrete sleepers on ballast made of class 1 crushed stone.

Transition concrete sleepers shall be placed on both tracks along 15m length before guard rails and 15m behind track expansion joint.

60E1 guard rails with elastic fastening system shall be laid on bridge structures and along 10.4 m length before and behind the bridge to serve as protection against harmful effects of train derailment. Flat concrete sleepers shall support running and guard rails that will rest on double steel base plates.
The bridge structure was treated in Volume 2/1-1.6 Design of the bridge at km 81+644.83.

Layout drawing shows the bridge as three-span steel structure with lattice girder in the central span. Rocker bearings will be mounted on piers S1, S3 and S4 while one fixed bearing will be mounted on pier S2.
Total length of the bridge structure is 56+56+42=154 m.

Elastomeric pads under 2.60 m long concrete sleepers in transition zone shall be placed along 25 m length before and behind the bridge that is under concrete sleepers on bridges for running and guard rails along 10.4 m length before the bridge and under concrete track transition sleepers along 15 m length before guard rail, and behind the bridge under concrere sleepers for track expansion joint and on the part of the transitionin sleepers order to increase the base elasticity and enable gradual change of rail deflection when ruling vehicle passes from the track on embankment to transition structure as well as from transition structure to bridge structure.

Since the bridge expansion length exceeds 40 m, the CRDC designer calculated the track-bridge interaction and it was taken from Volume No. 2/1-1.6 Design of the bridge at km 81+644.83

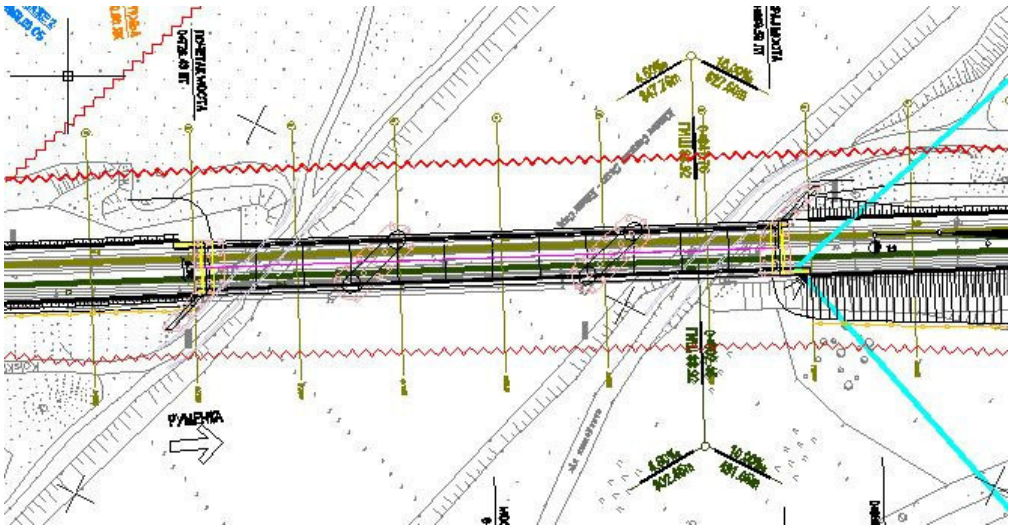
The calculation of the interaction has shown that it is necessary to install a rail expansion joint of a= ±200 mm minimum capacity above the end rocker bearing (pier S4) on both tracks at km 81+727.20 R.T. (km 81+721.83 L.T.).

The calculation was made under assumption that maximum longitudinal resistance during elastic rail movement through elastic fastening system is 30 kN/m, which corresponds to 9 kN longitudinal resistance force.

The calculation has shown that track is stable in horizontal plane and that compressive stress, tensile stress, maximum relative movements, absolute movements and horizontal movements due to turned ends of bridge superstructure under high train vertical load are within permitted limits when expansion joint of a= ±200 mm is used.

4. Technical description of the bridge at km 0+751.01 R.T. (0+796.33 L.T.), 138 m long

New bridge structure is designed at km 0+749.71 of the existing Novi Sad - Subotica double-track line at the place of existing bridge over the Novi Sad - Savino Selo canal. The bridge structure is treated in Volume 2/1-1.5 Design of the bridge at km 0+749.71. Center-to-center distance between tracks is reduced compared to the existing one from 7.0 m (two single-track bridges) to 4.75 m (newly designed double-track bridge). Tracks on the bridge are straight. Most of the track has an upgradient of 4.5‰ but behind third pier S3 the track has a downgradient of 10‰ with vertical curve radius of R=5000.00 m. Maximum speed on the bridge is 100 km/h.



Permanent way on the bridge structure is designed according to newly designed permanent way on open line. Both tracks are assembled of 60 E1 rails on 2.60 m long concrete sleepers on ballast made of class 1 crushed stone.

Transition concrete sleepers shall be placed on both tracks along 15m length before guard rails and 15m behind track expansion joint.

Transition concrete sleepers on the left freight track shall be placed along 15 m length before guard rails while 2.60 m long flat concrete sleepers - for zone between the switch and the bridge, 2.60m long shall be placed behind the bridge i.e. from the end of guard rails to the tip of switch 12 along 15.12 m length (from km 0+875.73 R.F. to km 0+890.85 R.T.).

60E1 guard rails with elastic fastening system shall be laid on bridge structures and along 10.4 m length before and behind the bridge to serve as protection against harmful effects of train derailment. Flat concrete sleepers shall support running and guard rails that will rest on double steel base plates.

Layout drawing shows the bridge as three-span steel structure with lattice girder in the central span. Rocker bearings will be mounted on piers S1, S3 and S4 while one fixed bearing will be mounted on pier S2.
Total length of the bridge structure is 27.60+82.80+27.60 = 138 m

Since the bridge expansion length exceeds 40 m, the CRDC designer calculated the track-bridge interaction and it was taken from Volume No. 2/1-1.5 Design of the bridge at km 0+796.33. The calculation of the interaction has shown that it is necessary to install a rail expansion joint of a= ±150 mm minimum capacity above the end rocker bearing (pier S4) on both tracks at km 0+820.01 R.T. (km 81+0+865.33 L.T.).

The calculation was made under assumption that maximum longitudinal resistance during elastic rail movement through elastic fastening system is 30 kN/m, which corresponds to 9 kN longitudinal resistance force.

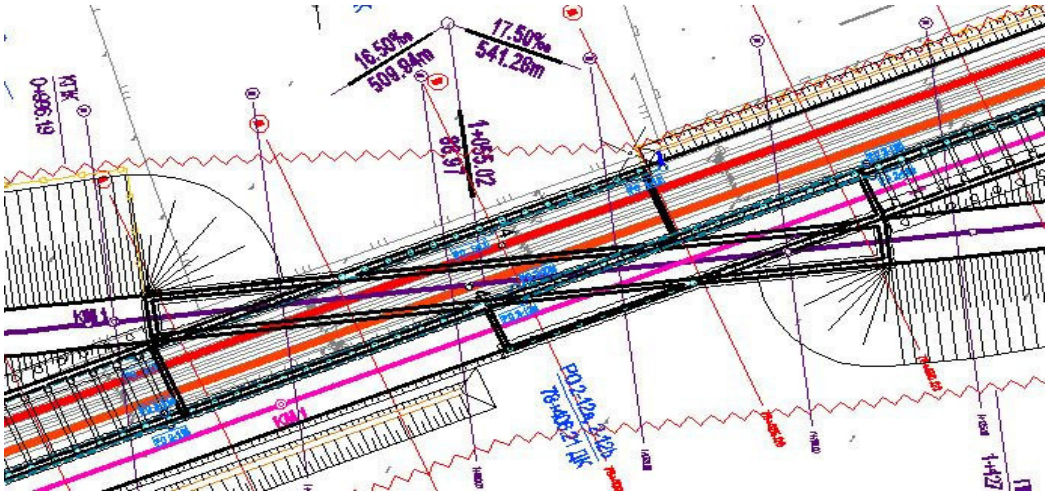
The calculation has shown that track is stable in horizontal plane and that compressive stress, tensile stress, maximum relative movements, absolute movements and horizontal movements due to turned ends of bridge superstructure under high train vertical load are within permitted limits when expansion joint of a= ±150 mm is used.

Elastomeric pads under 2.60 m long concrete sleepers in transition zone shall be placed along 14 m length before and behind the bridge that is under concrete sleepers on bridges for running and guard rails along 10.4 m length before the bridge and under transition concrete track sleepers along 3.6 m length before guard rail and behind the bridge under concrere sleepers for track expansion joint along 15.12 m in order to increase the base elasticity and enable gradual change of rail deflection when ruling vehicle passes from the track on embankment to transition structure as well as from transition structure to bridge structure.

5. Technical description of the gallery at km 78+401.27 R.T. (78+377.03 L.T.), 110 m long

Connecting track No. 1 runs at different level above the Novi Sad - Subotica - State border main railway line and connecting track No. 2. A gallery treated in Volume 2/1-1.3 Design of the gallery at km 78+401.27 is designed at grade-separation point, km 78+401.27 RT = km 1+036.22 VK1.
A single-track line - connecting track No. 1 is designed on the gallery, while main double-track line shall be laid under the gallery. The connecting track lies in vertical curve of radius Rv=3000. The track has an upgradient of 16.50‰ to the midst of gallery and therefrom the track has a

downgradient of 17.50‰. The maximum speed on connecting track No. 1 across the gallery is 65 km/h. Track on the bridge is straight.



The connecting track assembled of 49 E1 rails with elastic fastening system is laid on 2.40 m long concrete sleepers on ballast made of class 1 crushed stone.

49E1 guard rails with elastic fastening system shall be laid on bridge structures and along 10.4 m length before and behind the bridge to serve as protection against harmful effects of train derailment. Flat concrete sleepers shall support running and guard rails that will rest on double steel base plates.

Transition concrete sleepers shall be placed on both tracks along 15 m length before and behind guard rails.

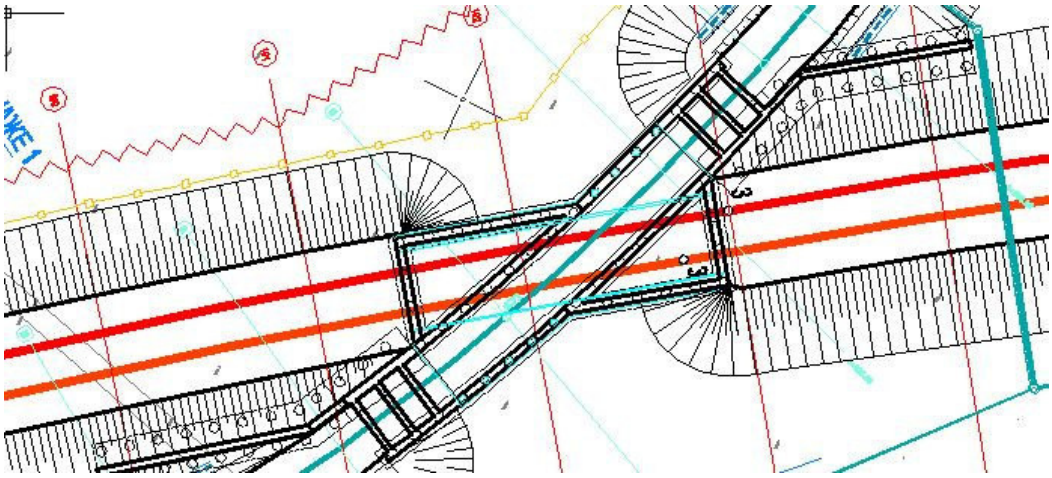
Structural system of the gallery is two-span frame. Supporting structure consists of reinforced concrete slab and reinforced concrete walls, 110 m long.

The bridge structure was treated in Volume 2/1-1.5 Design of the gallery at km 78+401.27.

Elastomeric pads under 2.40 m long concrete sleepers in transition zone shall be placed along 10.4 m length before and behind the bridge that is under concrete sleepers on bridges for running and guard rails in order to increase the base elasticity and enable gradual change of rail deflection when ruling vehicle passes from the track on embankment to transition structure as well as from transition structure to bridge structure.

6. Technical description of the gallery at km 81+283.13 R.T. (81+284.54 L.T.), 38 m long

The railway line to Bogojevo runs at different level under the tracks of the main railway line through the gallery at km 81+283.13. The gallery was treated in Volume 2/1-1.4 Design of the gallery at km 81+283.13. The main double-track line was designed on the gallery, while the single-track line to Bogojevo will be laid under the gallery. The tracks have an upgradient of 4.5‰. The maximum speed on the main tracks over gallery is 180 km/h. Tracks on the gallery lie in circular curve of 2000 m radius.



Permanent way on the bridge structures is designed according to newly designed permanent way on open line. Both tracks are assembled of 60 E1 rails on 2.60 m long concrete sleepers on ballast made of class 1 crushed stone.

60E1 guard rails with elastic fastening system shall be laid on bridge structures and along 10.4 m length before and behind the bridge to serve as protection against harmful effects of train derailment. Flat concrete sleepers shall support running and guard rails that will rest on double steel base plates.

Transition concrete sleepers shall be placed on both tracks along 15 m length before and behind guard rails.

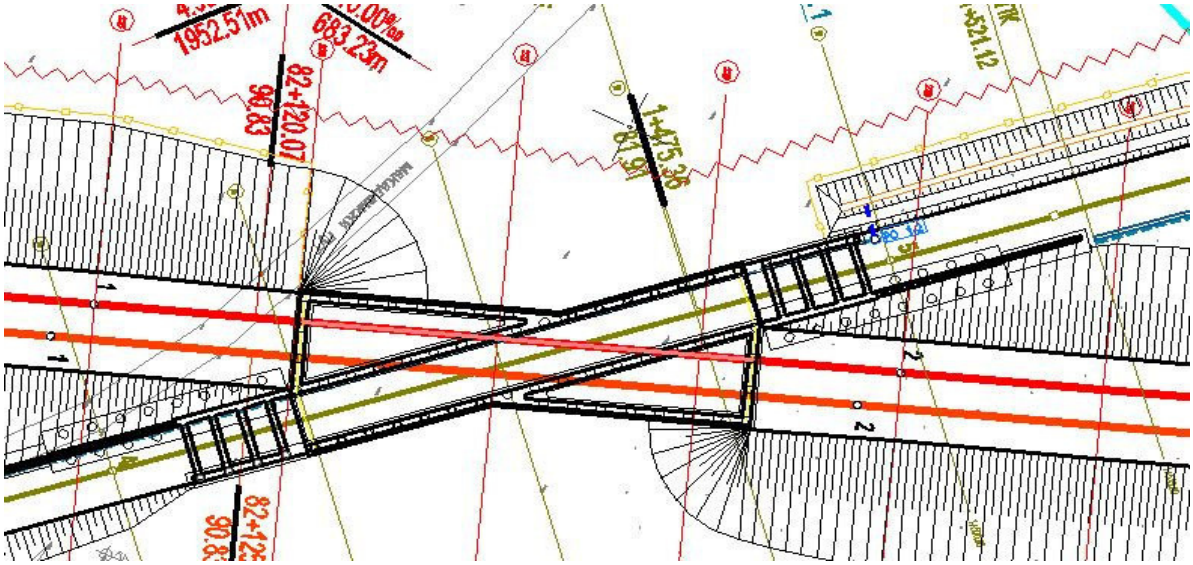
Statically, the gallery is frame structure. Supporting structure consists of reinforced concrete slab and reinforced concrete walls, 38 m long.

The investment value of permanent way was specified in the Design of track alignment and stations – substructure and permanent way – Novi Sad station, Volume 2/2-1.1. This design includes cost estimates only for procurement, transport and unloading of elastic rail pads under concrete sleepers and transition sleepers.

Elastomeric pads under 2.60 m long concrete sleepers in transition zone shall be placed along 25 m length before and behind the bridge that is under concrete sleepers on bridges along 10.4 m length before and behind the bridge and under transition concrete track sleepers along 15 m length before and behind guard rail in order to increase the base elasticity and enable gradual change of rail deflection when ruling vehicle passes from the track on embankment to transition structure as well as from transition structure to bridge structure.

7. Technical description of the gallery at km 82+152.69 R.T. (82+153.77 L.T.), 57 m long

The left freight track runs at different level under the tracks of the main railway line through the gallery at km 1+459.58 LT= km 82+152.69 RT. The gallery is treated in Volume 2/1-1.7 Design of the gallery at km 82+152.69.
The main double-track line is designed on the gallery, while the single-track line - left freight track will be laid under the gallery. The main tracks lie in vertical curve of radius Rv=20000. The tracks have a downgradient of 10.00‰. The maximum speed on the main tracks across gallery is 200 km/h. Tracks on the gallery are straight.



Permanent way on the bridge structures is designed according to newly designed permanent way on open line. Both tracks are assembled of 60 E1 rails on 2.60 m long concrete sleepers on ballast made of class 1 crushed stone.

60E1 guard rails with elastic fastening system shall be laid on bridge structures and along 10.4 m length before and behind the bridge to serve as protection against harmful effects of train derailment. Flat concrete sleepers shall support running and guard rails that will rest on double steel base plates.

Transition concrete sleepers shall be placed on both tracks along 15 m length before and behind guard rails.

Statically, the gallery is frame structure. Supporting structure consists of reinforced concrete slab and reinforced concrete walls, 57 m long.

Elastomeric pads under 2.60 m long concrete sleepers in transition zone shall be placed along 27.20 m length before and behind the bridge that is under concrete sleepers on bridges for running and guard rails along 10.4 m length before and behind the bridge and under transition concrete track sleepers along 16.8 m length before and behind guard rail in order to increase the base elasticity and enable gradual change of rail deflection when ruling vehicle passes from the track on embankment to transition structure as well as from transition structure to bridge structure.

Bridge structures and galleries on the Novi Sad - Rumenka Entry section

No.	Km point	Bridge spans (m)	Bridge length (m))
1	Bridge at km 76+615.57 R.T. (76+601.02 L.T.)	11.60+17.40+11.60	40.60
2	Bridge at km 77+814.32 R.T. (77+807.99 L.T.)	11.60 +18.85+11.60	42.05
3	Bridge at km 81+650.20 R.T. (81+644.83 L.T.) Savino Selo - Novi Sad canal	56+56+42	154
4	Bridge at km 0+751.01 R.T. (0+796.33 L.T.) Savino Selo - Novi Sad canal	27.60+82.80+27.60	138
5	Gallery at km 78+401.27 R.T. (78+377.03 L.T.)	two-span frame structural system	110
6	Gallery at km 81+283,13 R.T. (81+284.54 L.T.)	frame structural system	38
7	Gallery at km 82+152.69 R.T. (82+153.77 L.T.)	frame structural system	57

8. INVESTMENT VALUE OF WORKS

The value of works was estimated in the Priced Bill of Quantities. The investment value of works was determined based on the quantity measurement notes and unit prices of items.
The Priced Bill of Quantities includes all works envisaged in this design. Type and description of works are provided according to parameters for construction of new railway lines which are currently applied in constructing this type of facility.
The Priced Bill of Quantities was prepared based on data processed in the office, layout plans, computer processed data and average prices for this type of works according to the provided description of items.
The unit prices are expressed in dinars (RSD) based on average prices from the tender and technical documentation for similar facilities and type of works. The Priced Bill of Quantities specified the value of works on permanent way as well as the summary of works by types for this design.

GRAND SUMMARY

2/2-6.1.6.1	BRIDGE AT KM 81+650.20 R.T. (81+644.83 L.T.)	44.738.594,00
2/2-6.1.6.2	BRIDGE AT 0+751.01 R.T. (0+796.33 L.T.)	42.655.753,00
2/2-6.1.6.3.	GALLERY AT KM 78+401,27 R.T. (78+377.03L.T.)	9.552.178,00
2/2-6.1.6.4	GALLERY ATKM 82+152,69 R.T. (82+153.77 L.T.)	14.850.246,00
2/2-6.1.6.5	COST ESTIMATE FOR PERMANENT WAY WHICH WAS NOT INCLUDED IN THE DESIGN OF TRACK ALIGNMENT AND STATIONS – SUBSTRUCTURE AND PERMANENT WAY - NOVI SAD STATION, VOLUME 2/2-1.1 FOR THE BRIDGES AT KM 76+615.57 D.T. (76+601.02 L.T.) AND KM 77+814.32 R.T. (77+807.99 L.T.), AND FOR THE GALLERY AT KM 81+283.13 R.T. (81+284.54 L.T.)	4.280.044,00

TOTAL (RSD): **116.076.815,00**

During the works execution, all works related to signaling-interlocking system, telecommunication system, overhead catenary system, water supply system and mechanical installations must be synchronized with earthworks required for construction of track substructure.

RESPONSIBLE DESIGNER:

Dragana Jokanović, Grad. Civ. Eng.

License No. 315 1404 03 issued by
the Serbian Chamber of Engineers

2/2-6.1.6. NUMERICAL DOCUMENTATION

2/2-6.1.6.0 QUANTITIES MEASUREMENT NOTES

Evidence for the upper machine for bridge structures over 40m long
Section Novi Sad-Rumenka (exit)

1.Bridge on km 81+650,20 right track, (km 81+644,83 left track), L=154m

2/2.04.00 PERMANENT WAY - PROCUREMENT

2/2.04.01-1 RAIL TYPE 60E1.

Left main track:
154+2x10,4..... L=174,80m
Right main track:
154+2x10,4..... L=174,80m

Protective rail:
Left main track:
154+2x10,4..... L=174,80m
Right main track:
154+2x10,4..... L=174,80m
(174,80x4)m x 2 x 60.21kg/m……=84.197,66kg…….=**84.20t**

2/2.04.02-2 CONCRETE SLEEPERS ON BRIDGES, 2.60m LONG

with a flat upper surface on which they are mounted via double steel base plates

driving and safety rail

174,80x2 / 0.6.....=584pcs.

2/2.04.02-6 TRANSITION CONCRETE SLEEPERS, 2.60m LONG

Left and right track of the main line in front of and behind the concrete thresholds on the bridges
2x15x2 / 0.6.....=100pcs

2/2.04.02-2a ELASTOMERIC PADS UNDER TRANSITION CONCRETE SLEEPERS, 2.60m LONG

The length of the transition zone is about 15m

Under the concrete sleepers in front of and behind the safety rail, l=15m

2x15/0.6.....=50pcs

Under the transition concrete sleepers behind the track expansion joints.
2x5/0,6.....=18 pcs

2/2.04.02-3a ELASTOMERIC PADS UNDER CONCRETE SLEEPERS ON BRIDGES, 2.60m LONG
The length of the transition zone is about 10.4m

Below the concrete sleepers on the bridges on the part of the safety rail in front of and behind the bridge, l=10.4m

2x10.4/0.6.....=36pcs

2/2.04.02-5a ELASTOMERIC PADS UNDER CONCRETE SLEEPERS FOR TRACK EXPANSION JOINTS, 2.60m LONG
2x20/0.6.....=68 pcs

2/2.04.03-3 FASTENING SYSTEM FOR RUNNING RAIL AND CHECK RAIL, TYPE 60E1

.....=584set

2/2.04.03-9 JOINING PIECES FOR JOINTS IN CHECK RAILS ON BRIDGES

(174,80/25 -1)x4.....=24set

2/2.04.04-2 TRACK EXPANSION JOINTS CAPACITY ±200 mm

1x2 .....=2pcs

2/2.04.05 CRUSHED STONE, CATEGORY I

6.60x174.80.....1154m^3

2/2.04.06-1 WELDING SET FOR AT WELDING OF 60E1 RAILS IN LONG RAIL LENGHTS

Expansion joints:
4 x 2.....=8pcs

2/2.05.00 PERMANENT WAY – MATERIAL HANDLING

2/2.05.01 RAIL UNLOADING

.....=84.20t

2/2.05.02 UNLOADING OF CONCRETE SLEEPERS

.....=684pcs

2/2.05.03 UNLOADING OF ELASTIC TRACK FASTENINGS

584 * 15..... =8760kg.....=8,80t

2/2.05.04-1 UNLOADING OF TRACK EXPANSION JOINTS

.....=2pcs

2/2.06.00 PERMANENT WAY - WORKS

2/2.06.04-1 ASSEMBLY AND LAYING TRACK ON CONCRETE SLEEPERS, FIXING IT WITH ELASTIC TRACK FASTENINGS, RAIL TYPE 60E1

174.80x2..... L=0.35км

2/2.06.06 LAYING OF GUARD RAILS

.....L=0.35км

2/2.06.07 INSTALLATION OF TRACK EXPANSION DEVICES

.....2pcs

2/2.06.07-1 MECHANIZED LEVELLING AND DYNAMIC STABILIZATION OF TRACK ON CONCRETE SLEEPERS, RAIL TYPE 60E1

..... L=0.35км

2/2.06.07-3-1 MECHANIZED ALIGMENT OF EXPANSION JOINT

.....2pcs

2/2.06.08-1 ELECTRIC RESISTANCE WELDING OF 60E1 RAILS TO FORM CWR

(174.80/ 50 +1) x 4 .....=20weld

2/2.06.08-5-1 ALUMINOTHERMIC WELDING OF EXPANSION JOINTS IN CWR

4x2.....=8weld

2/2.06.09-1 STRESS RELIEF IN RAILS 60E1 WITH FINAL WELDING

..... L=0.35km

2/2.06.09-4 STRESS RELIEF IN EXPANSION DEVICES AND FINAL WELDING

.....=2pcs

2/2.07.00 PERMANENT WAY - EQUIPMENT

2/2.07.01 **PROCUREMENT AND PLACING OF MARKERS**

long rail track control markings.....=4pcs

2.Bridge on km 0+751.01 Right track (0+796.33 Left track), L=138m

2/2.02.00 EARTHWORKS

2/2.02.02 **REMOVAL OF EXISTING BALAST**

10.4m in front of and behind the bridge structure
2.5x2x20.8..... =104m^3

2/2.04.00 PERMANENT WAY - PROCUREMENTS

2/2.04.01-1 **RAIL TYPE 60E1**

Left main track:
138+2x10,4..... L=158,80m
Right main track:
138+2x10,4..... L=158,80m

Protective rail:
Left main track:
138+2x10,4..... L=158,80m
Right main track:
138+2x10,4..... L=158,80m
(158,80x4)m x 2 x 60.21kg/m…….....=76.490,78kg.....=**76.49t**

2/2.04.02-2 **CONCRETE SLEEPERS ON BRIDGES, 2.60m LONG**

with a flat upper surface on which they are mounted over double steel washers

driving and safety rail

158,80x2 / 0.6.....=530pcs

2/2.04.02-6 **TRANSITION CONCRETE SLEEPERS, 2.60m LONG**
Left and right track of the main line in front of and behind the concrete thresholds on the bridges
3x15 / 0.6.....=75pcs

2/2.04.02-2a **ELASTOMERIC PADS UNDER TRANSITION CONCRETE SLEEPERS , 2.60m LONG**

The length of the transition zone is about 3.6m

2x3.6/0.6.....=12pcs

2/2.04.02-4a **ELASTOMERIC PADS UNDER CONCRETE SLEEPERS ON BRIDGES, 2.60m LONG**
2x10.4/0.6.....=36pcs

2/2.04.02-5a **ELASTOMERIC PADS UNDER CONCRETE SLEEPERS FOR TRACK EXPANSION JOINTS, 2.60m LONG**

2x15.12/0.6.....=52pcs

2/2.04.03-3 **FASTENING SYSTEM FOR RUNNING RAIL AND CHECK RAIL FOR CONCRETE SLEEPERS AND RAIL TYPE 60E1**

Rail fastening for running and safety rail

.....=530set

2/2.04.03-9 **JOINING PIECES FOR JOINTS IN CHECK RAILS ON BRIDGES**

(158,80/25 -1)x4.....=22set

2/2.04.04-2 **TRACK EXPANSION JOINTS ±150mm**

1x2 .....=2pcs

2/2.04.05 **CRUSHED STONE, CATEGORY I**

5,35x158.80.....850m^3

2/2.04.06-1 **WELDING SET FOR AT WELDING OF 60E1 RAILS IN LONG RAIL LENGTHS**

Expansion joints:
4 x 2.....=8pcs

2/2.05.00 PERMANENT WAY – MATERIAL HANDLING

2/2.05.01 **RAIL UNLOADING**

.....= 76.49t

2/2.05.02 **UNLOADING OF CONCRETE SLEEPERS**

.....=605pcs

2/2.05.03 **UNLOADING OF ELASTIC TRACK FASTENINGS**

Open track Novi Sad - Subotica
530 * 15..... =7950kg.....=8.0t
26*7.5.....=195 kg.....=0.2t
=8.20t

2/2.05.04-1 **UNLOADING OF TRACK EXPANSION JOINTS**

.....=2pcs

2/2.06.00 PERMANENT WAY - WORKS

2/2.06.01 **DISMANTLING OF EXISTING TRACK**

158.8x2..... L=318m..... L=0.32км

2/2.06.03-2 **DISMANTLING OF CHECK RAIL ON BRIDGES**

158.8x2..... L=318m

2/2.06.04-1 **ASSEMBLY AND LAYING TRACK ON CONCRETE SLEEPERS, FIXING IT WITH ELASTIC TRACK FASTENINGS, RAIL TYPE 60E1**

158.8x2..... L=318m

2/2.06.06 **LAYING OF GUARD RAILS**

158.8x2.....L=0.32км

2/2.06.07 **INSTALLATION OF TRACK EXPANSION DEVICES**

.....2pcs

2/2.06.07-1 **MECHANIZED LEVELLING AND DYNAMIC STABILIZATION OF TRACK ON CONCRETE SLEEPERS, RAIL TYPE 60E1**

..... L=0.32km

2/2.06.07-3-1 **MECHANIZED ALIGNMENT OF EXPANSION JOINTS**

.....2pcs

2/2.06.08-1 **ELECTRIC RESISTANCE WELDING OF 60E1 RAILS TO FORM CWR**

(158.80/ 50 +1) x 4 .....=16weld

2/2.06.08-5-1 **ALUMINOTHERMIC WELDING OF EXPANSION JOINTS IN CWR**

4x2.....=8pcs

2/2.06.09-1 **STRESS RELIEF IN RAILS 60E1 WITH FINAL WELDINGS**

..... L=0.32km

2/2.06.09-4 **STRESS RELIEF IN EXPANSION JOINTS AND FINAL WELDING**

.....=2pcs

2/2.07.00 PERMANENT WAY - EQUIPMENT

2/2.07.01 **PROCUREMENT AND INSTALLATION OF POSTS**

long rail track control markings.....=4 pcs

3. Gallery at km 78+401.27 Right track (78+377.03 Left track), L=110m

2/2.04.00 PERMANENT WAY - PROCUREMENT

2/2.04.01-2 **RAIL TYPE 49E1.**
10,4+110+10,4..... L=130.80m

Safety rail
10,4+110+10,4..... L=130.80m

(130.80x2) * 2* 49.39kg/m .....= 25 840,85kg..... =**25.84t**

2/2.04.02-4 **CONCRETE SLEEPERS ON BRIDGES, 2.40m LONG**
Open track Novi Sad - Rumenka
130.80/0.6.....=218pcs

2/2.04.02-7 **TRANSITION CONCRETE SLEEPERS, 2.40m LONG**
Connecting track no.1
2x15 / 0.6.....=50pcs

2/2.04.02-6a **ELASTOMERIC PADS UNDER CONCRETE SLEEPERS ON BRIDGES, 2.40m LONG**

The length of the transition zone is about 10.4m

Under the concrete sleepers on the bridges on the part of the safety rail in front of and behind the bridge

l=10.4m

2x10.4/0.6.....=36pcs

2/2.04.03-4 **FASTENING SYSTEM FOR RUNNING RAIL AND CHECK RAIL FOR CONCRETE SLEEPERS AND RAIL TYPE 49E1**
.....=218set

2/2.04.03-10 **JOINING PIECES FOR JOINTS IN CHECK RAILS 49E1**

(130,80/25 -1)x2.....=10set

2/2.04.05 **CRUSHED STONE, CATEGORY I**

2.65x130.80.....347.00m^3

2/2.05.00 PERMANENT WAY – MATERIAL HANDLING

2/2.05.01 **RAIL UNLOADING**
.....=25.84t

2/2.05.02 **UNLOADING OF CONCRETE SLEEPERS**
…….=268pcs

2/2.05.03 **UNLOADING OF ELASTIC TRACK FASTENINGS**
218 * 15……3270kg……=3.3t

2/2.06.00 PERMANENT WAY - WORKS

2/2.06.04-2 **ASSEMBLY AND LAYING TRACK ON CONCRETE SLEEPERS, FIXING IT WITH ELASTIC TRACK FASTENINGS, RAIL TYPE 49E1**
…… L=130.80m……0.13km

.

2/2.06.06 **LAYING OF GUARD RAILS**
……L=130.80….. ...0.13km

2/2.06.07-2 **MECHANIZED LEVELLING AND DYNAMIC STABILIZATION OF TRACK ON CONCRETE SLEEPERS, RAIL TYPE 49E1.**
…… L=0.13км

2/2.06.08-2 **ELECTRIC RESISTANCE WELDING OF 49E1 RAILS TO FORM CWR**

(130.80/ 50 +1) x 2 ……=8weld

2/2.06.09-2 **STRESS RELIEF IN RAILS 49E1 WITH FINAL WELDING**
…… L=0.13km

2/2.07.00 PERMANENT WAY - EQUIPMENT

2/2.07.01 **PROCUREMENT AND INSTALLATION OF POSTS**

long rail track control markings……=2 pcs

4. Gallery at km 82+152.69 Right track (82+153.77 Left track), L=57m

2/2.04.00 PERMANENT WAY - PROCUREMENT

2/2.04.01-1 **RAIL TYPE 60E1.**

Left main track:
57+2x10,4…… L=77,80m
Right main track:
57+2x10,4…… L=77,80m

Safety rail:
Left main track:
57+2x10,4…… L=77,80m
Right main track:
57+2x10,4…… L=77,80m
(77,80x4)m x 2 x 60.21kg/m……=37.474,70kg……=37,48t

2/2.04.02-2 **CONCRETE SLEEPERS ON BRIDGES, 2.60m LONG**

with a flat upper surface on which they are mounted over double steel washers

driving and safety rail

77,80x2 / 0.6……=260pcs

2/2.04.02-6 **TRANSITION CONCRETE SLEEPERS, 2.60m LONG**

Left and right track of the main line in front of and behind the concrete thresholds on the bridges
2x15x2 / 0.6.....=100pcs

2/2.04.02-2a **ELASTOMERIC PADS UNDER TRANSITION CONCRETE SLEEPERS , 2.60m LONG**

The length of the transition zone is about 16.80m

Under the concrete sleepers in front of and behind the safety rail l= 16.80m

4x16.80/0.6.....=112pcs

2/2.04.02-3a **ELASTOMERIC PADS UNDER CONCRETE SLEEPERS ON BRIDGES, 2.60m LONG**
The length of the transition zone is about 10.40m
Under the concrete thresholds on the bridges on the part of the safety rail in front of and

behind the bridge l=10.4m

4x10.4/0.6.....=72pcs

2/2.04.03-3 **FASTENING SYSTEM FOR RUNNING RAIL AND CHECK RAIL FOR CONCRETE SLEEPERS AND RAIL TYPE 60E1**

.....=260set

2/2.04.03-9 **JOINING PIECES FOR JOINTS IN CHECK RAILS ON BRIDGES 60E1**

(77,80/25 -1)x4.....=12set

2/2.04.05 **CRUSHED STONE, CATEGORY I**

5,73x77.80.....446m^3

2/2.05.00 PERMANENT WAY – MATERIAL HANDLING

2/2.05.01 **RAIL UNLOADING**

.....= 37.48t

2/2.05.02 **UNLOADING OF CONCRETE SLEEPERS**

.....=360pcs

2/2.05.03 **UNLOADING OF ELASTIC TRACK FASTENINGS**
Open track Novi Sad - Rumenka
260 * 15..... =3900kg.....=3.9t

2/2.06.00 PERMANENT WAY - WORKS

2/2.06.04-1 **ASSEMBLY AND LAYING TRACK ON CONCRETE SLEEPERS, FIXING IT WITH ELASTIC TRACK FASTENINGS, RAIL TYPE 60E1.**

77.8x2..... L=0.16km

2/2.06.06 **LAYING OF GUARD RAILS**

77.8x2.....L=0.16км

2/2.06.07-1 **MECHANIZED LEVELLING AND DYNAMIC STABILIZATION OF TRACK ON CONCRETE SLEEPERS, RAIL TYPE 60E1.**

..... L=0.16km

2/2.06.08-1 **ELECTRIC RESISTANCE WELDING OF 60E1 RAILS TO FORM CWR**

(77.80/ 50 +1) x 4 .....=12weld

2/2.06.09-1 **STRESS RELIEF IN RAILS 60E1 WITH FINAL WELDING**

..... L=0.16km

2/2.07.00 PERMANENT WAY - EQUIPMENT

2/2.07.01 **PROCUREMENT AND INSTALLATION OF POSTS**

long rail track control markings.....=4 pcs

5. COST ESTIMATE FOR PERMANENT WAY WHICH WAS NOT INCLUDED IN THE DESIGN OF TRACK ALIGNMENT AND STATIONS – SUBSTRUCTURE AND PERMANENT WAY - NOVI SAD STATION, VOLUME 2/2-1.1 FOR THE BRIDGES AT KM 76+615.57 D.T. (76+601.02 L.T.) AND KM 77+814.32 R.T. (77+807.99 L.T.), AND FOR THE GALLERY AT KM 81+283.13 R.T. (81+284.54 L.T.)

2/2.04.00 PERMANENT WAY - PROCUREMENT

2/2.04.02-2-1 **FLAT CONCRETE SLEEPERS - FOR ZONE BETWEEN THE SWITCH AND THE BRIDGE, 2.60m LONG**

with a flat upper surface on which it is mounted over steel base plates
driving rail
bridge on km 76+615.57
right track of the main line
76+672,79(ПС9)–76+534,41 (КС4) - (40,6+2x10,40)
76.98 / 0.6.....=129pcs
freight track
6.76/0.6.....=12pcs
∑=141pcs

2/2.04.02-6 **TRANSITION CONCRETE SLEEPERS, 2.60m LONG**

Bridge on km 76+.615.57 Right track

Freight track from km 76+649,09 right track to km 76+664.09 right track
15 / 0.6.....=25pcs

Bridge on km 77+814.32
at 15m in front of and behind the protective rail
15x2x4/0.6.....=200pcs

Bridge on km 81+283,13
at 15m in front of and behind the protective rail
15x2x2/0.6.....=100pcs

2/2.04.02-2a **ELASTOMERIC PADS UNDER TRANSITION CONCRETE SLEEPERS , 2.60m LONG**

Bridge on km 76+615.57, L=40.60m, length of the transition zone 15m
Freight track behind the protective rail 4.6/0.6.....8pcs

Galleries at km 81+283,13 L=38m

The length of the transition zone is about 15m

Under the transitiin sleepers in front of and behind the safety rail L=15m

4x15/0.6.....100pcs

2/2.04.02-3a **ELASTOMERIC PADS UNDER CONCRETE SLEEPERS ON BRIDGES, 2.60m LONG**

Bridge on km 76+615.57, L=40.60m, length of the transition zone 15m

Left track of the main line in front of and behind the bridge 5,1/0,6.....10pcs
Right track of the main line in front of and behind the bridge 2x10,4/0,6.....36pcs

Freight track line in front of and behind the bridge 2x10.4/0.6.....36pcs

∑= **82pcs**

Bridge on km 77+814.32, L=42.5m
Main tracks in front of and behind the bridge on the length of the protective rail of 10.40 m
4x2x10.4/0.6.....=**144pcs**

Galleries at km 81+283,13 (81+284.54 Left track), L=38m

Below the concrete sleepers on the bridges on the part of the safety rail in front of and behind the bridge at a distance of 10.4m

4x10.4/0.6.....=72pcs

2/2.04.02-4a ELASTOMERIC PADS UNDER FLAT CONCRETE SLEEPERS - FOR ZONE BETWEEN THE SWITCH AND THE BRIDGE, 2.60m LONG

Bridge on km 76+615.57, L=40.60m, length of the transition zone 15m

Right track of the main line in front of and behind the bridge 2x4.6/0,6.....14pcs
Freight track from turnout No. 6 to the beginning of the safety rail 6.76/0.6.....11pcs

∑= **25pcs**

2/2.04.03-3a FASTENING SYSTEM FOR RUNNING RAIL FOR FLAT CONCRETE SLEEPERS - FOR ZONE BETWEEN THE SWITCH AND THE BRIDGE AND RAIL TYPE 60E1

Rail mounting for running rail.....=141set

2/2.05.00 PERMANENT WAY – MATERIAL HANDLING

2/2.05.02 UNLOADING OF CONCRETE SLEEPERS.....=466pcs

2/2.05.03 UNLOADING OF ELASTIC TRACK FASTENINGS
141x7.5.....=1058kg.....=1.06t

Responsible Designer

Dragana Jokanović, Grad.Civ.Eng.

2/2-6.1.6.1 INVESTMENT VALUE OF PERMANENT WAY FOR THE BRIDGE STRUCTURE AT KM 81+650,20 R.T.(81+644.83 L.T.)

САОБРАЋАЈНИ ИНСТИТУТ ЦИП д.о.о.
Немањина 6/IV, 11000 Београд

1.- Priced bill of quantities of bridge superstructure, 154 m long at km 81+650.20 R.T. (81+644.83 L.T.)

Novi Sad- Rumenka exit section

Item	Description	MU	Quantity	Unit price (RSD)	Total (RSD)
			A	B	AxB
2/2.04.00	**PERMANENT WAY - PROCUREMENT**				
2/2.04.01-1	**RAIL TYPE 60E1** The item includes procurement and delivery to site of rail type 60E1, quality R260 according to EN13674 - 1 , in minimum 50m lengths Measurement and payment per ton of delivered rails. bridge at km 81+650.20, L=154m	t	84,20	125.000,00	10.524.708,00
2/2.04.02-2	**CONCRETE SLEEPERS ON BRIDGES, 2.60m LONG** The item includes procurement and delivery to site of concrete sleepers, 2.60m long for 60E1 rail and check rail with double base plates and rubber pads, according to SRPS EN13481-2. Measurement and payment per piece.	pcs	584	8.800,00	5.139.200,00
2/2.04.02-6	**TRANSITION CONCRETE SLEEPERS, 2.60m LONG** The item includes procurement and delivery to site of transition concrete sleepers,rail type 60 E1, L=2,60 m, Measurement and payment per piece.	pcs	100	5.050,00	505.000,00
2/2-04.02-2a	**ELASTOMERIC PADS UNDER TRANSITION CONCRETE SLEEPERS , 2.60m LONG** The item includes procurement, transport and delivery of elastic rail pads to concrete sleeper factory where they will be installed. Measurement and payment per each elastomeric rail pad. for concrete sleepers, 2.60m long	pcs.	68	3.000,00	204.000,00

Item	Description	MU	Quantity	Unit price (RSD)	Total (RSD)
			A	B	AxB
2/2-04.02-3a	**ELASTOMERIC PADS UNDER CONCRETE SLEEPERS ON BRIDGES** The item includes procurement, transport and delivery of elastic rail pads to concrete sleeper factory where they will be installed. Measurement and payment per each elastomeric rail pad. for concrete sleepers on bridges, 2.60m long	pcs.	36	3.000,00	108.000,00
2/2-04.02-5a	**ELASTOMERIC PADS UNDER CONCRETE SLEEPERS FOR TRACK EXPANSION JOINTS** The item includes procurement, transport and delivery of elastic rail pads to concrete sleeper factory where they will be installed. Measurement and payment per each elastomeric rail pad. for concrete sleepers on bridges, 2.60m long	pcs.	68	3.000,00	204.000,00
2/2.04.03-3	**FASTENING SYSTEM FOR RUNNING RAIL AND CHECK RAIL, TYPE 60E1.** The item includes procurement and delivery to site of rail fastenings for running rail (60E1) and check rail (60E1) for concrete sleepers according to SRPS EN 13481. Measurement and payment per set/sleeper of delivered fastenings. bridge at km 81+650.20, L=154m	set	584	4.600,00	2.686.400,00
2/2.04.03-9	**JOINING PIECES FOR JOINTS IN CHECK RAILS ON BRIDGES**. The item includes procurement and delivery to site of joining pieces for joints in 60E1 check rails. Measurement and payment per joining pieces for one joint.				
	bridge at km 81+650.20, L=154m	pcs.	24	5.000,00	120.000,00
2/2.04.04-2	**TRACK EXPANSION JOINTS.** The item includes procurement and delivery to site of track expansion joints capacity ±100 stroke with concrete sleepers and rail fastenings. Measurement and payment per each delivered expansion joint.				
	bridge at km 81+650.20, L=154m	pcs.	2	4.800.000,00	9.600.000,00

Item	Description	MU	Quantity	Unit price (RSD)	Total (RSD)
			A	B	AxB
2/2-04.05	**CRUSHED STONE, CATEGORY 1** The item includes procurement of crushed stone, its transport in FAD wagons to site and placing. Crushed stone grading shall comply with instruction for acceptance and delivery of crushed stone for track ballast on Serbian railways, and SRPS EN 13450. Measurement and payment per m^3 of compacted crushed stone placed in track.				
	bridge at km 81+650.20, L=154m	m^3	1.154,00	4.200,00	4.846.800,00
2/2-.04.06-1	**WELDING SET FOR AT WELDING OF 60E1 RAILS IN LONG RAIL LENGTHS** The item includes procurement and delivery to site of AT welding sets for rail welding. Measurement and payment per				
	bridge at km 81+650.20, L=154m	pcs.	8	6.000,00	48.000,00
				SUBTOTAL PERMANENT WAY - PROCUREMENT:	**33.986.108,00**
2/2-.05.00	**PERMANENT WAY - MATERIAL HANDLING**				
2/2.05.01	**RAIL UNLOADING.** The item includes unloading of rails from wagons and their local transport to the point of track installation. Measurement for payment per tonne of delivered rails.	t	84,20	2.700,00	227.336,00
2/2.05.02	**UNLOADING OF CONCRETE SLEEPERS** The item includes unloading of concrete track and transition sleepers from wagon and transfer to and stacking on site. Measurement and payment per each unloaded sleeper.	pcs.	684	370,00	253.080,00
2/2.05.03	**UNLOADING OF ELASTIC TRACK FASTENINGS** The Item includes unloading of elastic track fastenings from wago, transfer to and storage in site store. Measurement and payment per ton of unloaded fastenings	t	8,80	2.900,00	25.520,00
2/2.05.04-1	**UNLOADING OF TRACK EXPANSION JOINTS.** The item includes unloading of track expansion joints.	pcs.	2	35.100,00	70.200,00
				SUBTOTAL PERMANENT WAY - HANDLING:	**576.136,00**

Item	Description	MU	Quantity	Unit price (RSD)	Total (RSD)
			A	B	AxB
2/2.06.00	**PERMANENT WAY - WORKS**				
2/2.06.04-1	**ASSEMBLY AND LAYING TRACK ON CONCRETE SLEEPERS, FIXING IT WITH ELASTIC TRACK FASTENINGS, RAIL TYPE 60E1.** The Item includes assembly and laying of track onto concrete sleepers, fixing elastic track fastenings, rail type 60E1. Measurement and payment per km of assembled and laid track.				
	bridge at km 81+650.20, L=154m	km	0,35	6.105.000,00	2.136.750,00
2/2.06.06	**LAYING OF GUARD RAILS.** The item includes transport, handling and laying of guard rails and all required rail fastenings. Payment per km of both guard rails.				
	bridge at km 81+650.20, L=154m	km	0,35	7.200.000,00	2.520.000,00
2/2.06.07	**INSTALLATION OF TRACK EXPANSION DEVICES.** The item includes installation of track expansion devices. Measurement and payment per each installation expansion devices.				
	bridge at km 81+650.20, L=154m	pcs.	2	700.000,00	1.400.000,00
2/2.06.07-1	**MECHANIZED LEVELLING AND DYNAMIC STABILIZATION OF TRACK ON CONCRETE SLEEPERS, RAIL TYPE 60E1** The item includes placing of crushed stone in track, raising of track to required reference level with cant and enlargement in curves, tamping, mechanized aligning of track on the bed and on bridges. on concrete sleepers, with elastic track fastenings, rail type 60E1, formation of ballast prism and maintenance till take-over. Measurement and payment per km of finally levelled track in designed position.				
	bridge at km 81+650.20, L=154m	km	0,35	5.200.000,00	1.820.000,00

Item	Description	MU	Quantity	Unit price (RSD)	Total (RSD)
			A	B	AxB
2/2.06.07-3-1	**MECHANIZED ALIGNMENT OF EXPANSION JOINTS.** The item includes placing of ballast, tamping, mechanized aligning and levelling and dynamic stabilization of expansion joints on concrete sleepers as well as ballast bed finishing and maintenance until taking over. Measurement and payment per each aligned expansion joint.				
	bridge at km 81+650.20, L=154m	pcs.	2	400.000,00	800.000,00
2/2.06.08-1	**ELECTRIC RESISTANCE WELDING OF 60E1 RAILS TO FORM CWR** The item includes electric resistance welding of rails in 300 m long sections, finish and testing of welds, and provision of weld quality certificates for 60E1 rail type. Measurement and payment per weld.				
	bridge at km 81+640, L=160m	weld	20,00	32.500,00	650.000,00
2/2.06.08-5-1	**ALUMINOTHERMIC WELDING OF EXPANSION JOINTS IN CWR.** The item includes aluminothermic welding of expansion joints in CWR, procurement of all necessary welding materials, weld treatment and test and provision of weld quality certificate. Measurement and payment per weld.				
	bridge at km 81+650.20, L=154m	weld	8,00	36.000,00	288.000,00
2/2.06.09-1	**STRESS RELIEF IN RAILS 60E1 WITH FINAL WELDING.** The item includes stress relief in rails with final welding. Measurement for payment per km of track.				
	bridge at km 81+650.20, L=154m	km	0,35	720.000,00	252.000,00
2/2.06.09-4	**STRESS RELIEF IN EXPANSION DEVICES AND FINAL WELDING.** The item includes stress relief in expansion devices and final welding. Measurement and payment per piece expansion joints.				
	bridge at km 81+650.20, L=154m	pcs.	2	132.000,00	264.000,00

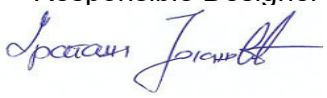
SUB TOTAL PERMANENT WAY - WORKS:	**10.130.750,00**

Item	Description	MU	Quantity	Unit price (RSD)	Total (RSD)
			A	B	AxB
2/2.07.00	**PERMANENT WAY - EQUIPMENT**				
2/2.07.01	**PROCUREMENT AND PLACING OF MARKERS** The item includes procurement and placing 100 m, km, curve markers and check markers for long rail levels. Measurement and payment per sign and markers.				
	bridge at km 81+650.20, L=154m	pcs.	4,00	11.400,00	45.600,00
	SUBTOTAL PERMANENT WAY - TRACK EQUIPMENT:				**45.600,00**

GRAND SUMMARY

2/2.04.00	**PERMANENT WAY - PROCUREMENT**	**33.986.108,00**
2/2-.05.00	**PERMANENT WAY-HANDLING**	**576.136,00**
2/2.06.00	**PERMANENT WAY-WORKS**	**10.130.750,00**
2/2.07.00	**PERMANENT WAY- EQUIPMENT**	**45.600,00**
	TOTAL (RSD):	**44.738.594,00**

Responsible Designer



Dragana Jokanovic, Grad.Civ.Eng.

2/2-6.1.6.2 INVESTMENT VALUE OF PERMANENT WAY FOR THE BRIDGE STRUCTURE AT KM 0+751.01 R.T. (0+796,33 L.T.)

2.- Priced bill of quantities of bridge superstructure, 138 m long at km 0+751.01 R.T. (0+796.33 L.T.) Novi Sad- Rumenka exit section

Item	Description	MU	Quantity	Unit price (RSD)	Total (RSD)
			A	B	AxB
2/2.02.00	**EARTHWORKS**				
2/2.02.02	**REMOVAL OF EXISTING BALLAST** The Item includes removal of existing ballast with a machine from existing track. This means loading, haulage to 10 km, unloading and levelling or storage of material. The investor may decide upon reuse of removed crushed stone dependent on its quality. Measurement and payment per m3 of removed ballast. 10,4meters before and behind the bridge	m^3	104,00	985,00	102.440,00
				TOTAL EARTHWORKS:	**102.440,00**
2/2.04.00	**PERMANENT WAY - PROCUREMENT**				
2/2.04.01-1	**RAIL TYPE 60E1.** The item includes the procurement and delivery to site of rails type 60E1, quality R260 according to EN13674 - 1 , min. length L=50 m. Measurement for payment per tonne of delivered rails. bridge at km 0+751.01, L=138m	t	76,49	125.000,00	9.561.348,00
2/2.04.02-2	**CONCRETE SLEEPERS ON BRIDGES, 2.60m LONG** The item includes procurement and delivery to site of concrete sleepers, 2.60m long for 60E1 rail and check rail with double base plates and rubber pads, according to SRPS EN13481-2. Measurement and payment per piece. bridge at km 0+751,01, L=138m	pcs.	530	8.800,00	4.664.000,00
2/2.04.02-6	**TRANSITION CONCRETE SLEEPERS, 2.60m LONG** The item includes procurement and delivery to site of transition concrete sleepers,rail type 60 E1, L=2,60 m, Measurement and payment per piece.	ком	75	5.050,00	378.750,00

Item	Description	MU	Quantity	Unit price (RSD)	Total (RSD)
			A	B	AxB
2/2.04.02-2a	**ELASTOMERIC PADS UNDER TRANSITION CONCRETE SLEEPERS, 2.60m LONG** The item includes procurement, transport and delivery of elastic rail pads to concrete sleeper factory where they will be installed. Measurement and payment per each elastomeric rail pad. for concrete sleepers, 2.60m long	pcs.	12	3.000,00	36.000,00
2/2-04.02-4a	**ELASTOMERIC PADS UNDER CONCRETE SLEEPERS ON BRIDGES , 2.60m LONG** The item includes procurement, transport and delivery of elastic rail pads to concrete sleeper factory where they will be installed. Measurement and payment per each elastomeric rail pad. for concrete sleepers on bridges, 2.60m long	pcs.	36	3.000,00	108.000,00
2/2-04.02-5a	**ELASTOMERIC PADS UNDER CONCRETE SLEEPERS FOR TRACK EXPANSION JOINTS , 2.60m LONG** The item includes procurement, transport and delivery of elastic rail pads to concrete sleeper factory where they will be installed. Measurement and payment per each elastomeric rail pad. for concrete sleepers on bridges, 2.60m long	pcs.	52	3.000,00	156.000,00
2/2.04.03-3	**FASTENING SYSTEM FOR RUNNING RAIL AND CHECK RAIL FOR CONCRETE SLEEPERS AND RAIL TYPE 60E1.** The item includes procurement and delivery to site of rail fastenings for running rail and check rail type 60E1 for concrete sleepers according SRPS EN 13481. Measurement and payment per set/sleeper of delivered fastenings bridge at km 0+751,01, L=138m	set	530	4.600,00	2.438.000,00

Item	Description	MU	Quantity	Unit price (RSD)	Total (RSD)
			A	B	AxB
2/2.04.03-3a	**FASTENING SYSTEM FOR RUNNING RAIL FOR FLAT CONCRETE SLEEPERS - FOR ZONE BETWEEN THE SWITCH AND THE BRIDGE AND RAIL TYPE 60E1** The item includes procurement and delivery to site of rail fastenings for running rail and check rail type 60E1 for concrete sleepers according SRPS EN 13481. Measurement and payment per set/sleeper of delivered fastenings	сет	26	2.300,00	59.800,00
2/2.04.03-9	**JOINING PIECES FOR JOINTS IN CHECK RAILS ON BRIDGES**. The item includes procurement and delivery to site of joining pieces for joints in 60E1 check rails. Measurement and payment per joining pieces for one joint.	pcs.	22	5.000,00	110.000,00
2/204.04-2	**TRACK EXPANSION JOINTS.** The item includes procurement and delivery to site of track expansion joints with concrete sleepers and rail fastenings. Measurement and payment per each delivered expansion joint.	pcs.	2	4.800.000,00	9.600.000,00
2/2.04.05	**CRUSHED STONE, CATEGORY 1** The item includes procurement of crushed stone, its transport in FAD wagons to site and placing. Crushed stone grading shall comply with instruction for acceptance and delivery of crushed stone for track ballast on Serbian railways, and SRPS EN 13450. Measurement and payment per m^3 of compacted crushed stone placed in track.	m^3	850,00	4.200,00	3.570.000,00
2/2.04.06-1	**WELDING SET FOR AT WELDING OF 60E1 RAILS IN LONG RAIL LENGTHS** The item includes procurement and delivery to site of AT welding sets for rail welding. Measurement and payment per delivered AT set.	pcs.	8	6.000,00	48.000,00

SUBTOTAL PERMANENT WAY - PROCUREMENT:	**30.729.898,00**

Item	Description	MU	Quantity	Unit price (RSD)	Total (RSD)
			A	B	AxB
2/2.05.00	**PERMANENT WAY - MATERIAL HANDLING**				
2/2.05.01	**RAIL UNLOADING.** The item includes unloading of rails from wagons and their local transport to the point of track installation. Measurement for payment per tonne of delivered rails.	t	76,49	2.700,00	206.525,00
2/2.05.02	**UNLOADING OF CONCRETE SLEEPERS** The item includes unloading of concrete track and transition sleepers from wagon and transfer to and stacking on site. Measurement and payment per each unloaded sleeper.	pcs.	605	370,00	223.850,00
2/2.05.03	**UNLOADING OF ELASTIC TRACK FASTENINGS** The Item includes unloading of elastic track fastenings from wago, transfer to and storage in site store. Measurement and payment per ton of unloaded fastenings	t	8,20	2.900,00	23.780,00
2/2.05.04-1	**UNLOADING OF TRACK EXPANSION JOINTS.** The item includes unloading of track expansion joints.	pcs.	2	35.100,00	70.200,00

SUBTOTAL PERMANENT WAY - HANDLING:	**524.355,00**

2/2.06.00	**PERMANENT WAY - WORKS**				
2/2.06.01	**DISMANTLING OF EXISTING TRACK.** The item includes dismantling of existing track and the track at deviations on track bed with loading, transport to 10 km distance, unloading, and stacking according to the kind and usability. Measurement for payment per km of dismantled track. bridge at km 0+751,01, L=138m	km	0,32	2.880.000,00	921.600,00
2/2.06.03-2	**DISMANTLING OF CHECK RAILS ON BRIDGES.** The item includes dismantling of check rails on bridges, loading, transport to 10 km distance, unloading and stacking by type and usability. Measurement and payment per m' of both dismantled check rails. bridge at km 0+751,01, L=138m	m	318,00	3.000,00	954.000,00

Item	Description	MU	Quantity	Unit price (RSD)	Total (RSD)
			A	B	AxB
2/2.06.04-1	**ASSEMBLY AND LAYING TRACK ON CONCRETE SLEEPERS, FIXING IT WITH ELASTIC TRACK FASTENINGS, RAIL TYPE 60E1.** The Item includes assembly and laying of track onto concrete sleepers, fixing elastic track fastenings, rail type 60E1. Measurement and payment per km of assembled and laid track. bridge at km 0+751,01, L=138m	km	0,32	6.105.000,00	1.938.948,00
2/2.06.06	**LAYING OF GUARD RAILS.** The item includes transport, handling and laying of guard rails and all required rail fastenings. Payment per km of both guard rails. bridge at km 0+751,01, L=138m	km	0,32	7.200.000,00	2.286.720,00
2/2.06.07	**INSTALLATION OF TRACK EXPANSION DEVICES.** The item includes installation of track expansion devices. Measurement and payment per each installation expansion devices. bridge at km 0+751,01, L=138m	pcs.	2	700.000,00	1.400.000,00
2/2.06.07-1	**MECHANIZED LEVELLING AND DYNAMIC STABILIZATION OF TRACK ON CONCRETE SLEEPERS, RAIL TYPE 60E1** The item includes placing of crushed stone in track, raising of track to required reference level with cant and enlargement in curves, tamping, mechanized aligning of track on the bed and on bridges. on concrete sleepers, with elastic track fastenings, rail type 60E1, formation of ballast prism and maintenance till take-over. Measurement and payment per km of finally levelled track in designed position. bridge at km 0+751,01, L=138m	km	0,32	5.200.000,00	1.651.520,00
2/2.06.07-3-1	**MECHANIZED ALIGNMENT OF EXPANSION JOINTS.** The item includes placing of ballast, tamping, mechanized aligning and levelling and dynamic stabilization of expansion joints on concrete sleepers as well as ballast bed finishing and maintenance until taking over. Measurement and payment per each aligned expansion joint. bridge at km 0+749,71, L=138m	pcs.	2	400.000,00	800.000,00

Item	Description	MU	Quantity	Unit price (RSD)	Total (RSD)
			A	B	AxB
2/2.06.08-1	**ELECTRIC RESISTANCE WELDING OF 60E1 RAILS TO FORM CWR** The item includes electric resistance welding of rails in 300 m long sections, finish and testing of welds, and provision of weld quality certificates for 60E1 rail type. Measurement and payment per weld. bridge at km 0+751,01, L=138m	weld	16,00	32.500,00	520.000,00
2/2.06.08-5-1	**ALUMINOTHERMIC WELDING OF EXPANSION JOINTS IN CWR.** The item includes aluminothermic welding of expansion joints in CWR, procurement of all necessary welding materials, weld treatment and test and provision of weld quality certificate. Measurement and payment per weld. bridge at km 0+751,01, L=138m	weld	8,00	36.000,00	288.000,00
2/2.06.09-1	**STRESS RELIEF IN RAILS 60E1 WITH FINAL WELDING.** The item includes stress relief in rails with final welding. Measurement for payment per km of track. bridge at km 0+751,01, L=147,02m	km	0,32	720.000,00	228.672,00
2/2.06.09-4	**STRESS RELIEF IN EXPANSION JOINTS AND FINAL WELDING.** The item includes stress relief in expansion joints and final welding. Measurement and payment per piece expansion joint. bridge at km 0+751,01, L=138m	pcs.	2	132.000,00	264.000,00

SUB TOTAL PERMANENT WAY - WORKS:	**11.253.460,00**

2/2.07.00	**PERMANENT WAY - EQUIPMENT**				
2/2.07.01	**PROCUREMENT AND INSTALLATION OF POSTS.** The item includes the procurement and installation marks for control of CWR. Measurement for payment per piece of installed posts bridge at km 0+749,71, L=138m	pcs.	4,00	11.400,00	45.600,00

SUBTOTAL PERMANENT WAY - TRACK EQUIPMENT:	**45.600,00**

Item	Description	MU	Quantity	Unit price (RSD)	Total (RSD)
			A	B	AxB

GRAND SUMMARY

2/2.02.00	**EARTHWORKS**	**102.440,00**
2/2.04.00	**PERMANENT WAY - PROCUREMENT**	**30.729.898,00**
2/2.05.00	**PERMANENT WAY- HANDLING**	**524.355,00**
2/2.06.00	**PERMANENT WAY-WORKS**	**11.253.460,00**
2/2.07.00	**PERMANENT WAY- EQUIPMENT**	**45.600,00**

TOTAL (RSD): **42.655.753,00**

Responsible Designer

Dragana Jokanovic, Grad.Civ.Eng.

2/2-6.1.6.3 INVESTMENT VALUE OF PERMANENT WAY FOR THE BRIDGE STRUCTURE AT KM 78+401.27 R.T. (78+377,03 L.T.)

САОБРАЋАЈНИ ИНСТИТУТ ЦИП д.о.о.
Немањина 6/IV, 11000 Београд

3.- Priced bill of quantitiesof gallerie superstructure, 110 m long at km 78+401,27 R.T. (78+377.03 L.T.) Novi Sad- Rumenka exit section

Item	Description	MU	Quantity	Unit price (RSD)	Total (RSD)
			A	B	AxB
2/2.04.00	**PERMANENT WAY - PROCUREMENT**				
2/2.04.01-2	**RAIL TYPE 49E1.** The item includes the procurement and delivery to site of rails type 49E1, quality R260 according to EN13674 - 1 , min. length L=50 m. Measurement for payment per tonne of delivered rails. gallerie at km 78+401.27	t	25,84	105.000,00	2.713.200,00
2/2.04.02-4	**CONCRETE SLEEPERS ON BRIDGES, 2.40m LONG** The item includes procurement and delivery to site of flat concrete sleepers, 2.40m long for rail type 49E1 with quard rail and rail fastening system according to SRPS EN13481-2. Measurement and payment per piece. gallerie at km 78+401.27	pcs.	218	7.800,00	1.700.400,00
2/2.04.02-7	**TRANSITION CONCRETE SLEEPERS, 2.40m LONG** The item includes procurement and delivery to site of transition concrete sleepers,rail type 49 E1, L=2,40 m, Measurement and payment per piece.	ком	50	4.500,00	225.000,00
2/2-04.02-6a	**ELASTOMERIC PADS UNDER CONCRETE SLEEPERS, ON BRIDGES 2.40 m LONG** The item includes procurement, transport and delivery of elastic rail pads to concrete sleeper factory where they will be installed. Measurement and payment per each elastomeric rail pad. for concrete sleepers on bridges, 2.40m long	pcs.	36	2.500,00	90.000,00

Item	Description	MU	Quantity	Unit price (RSD)	Total (RSD)
			A	B	AxB
2/2.04.03-4	**FASTENING SYSTEM FOR RUNNING RAIL AND CHECK RAIL FOR CONCRETE SLEEPERS AND RAIL TYPE 49E1.** The item includes procurement and delivery to site of rail fastenings for running rail and check rail type 49E1 for concrete sleepers according SRPS EN 13481. Measurement and payment per set/sleeper of delivered fastenings gallerie at km 78+401.27	set	218	2.900,00	632.200,00
2/2.04.03-10	**JOINING PIECES FOR JOINTS IN CHECK RAILS ON BRIDGES**. The item includes procurement and delivery to site of joining pieces for joints in 49E1 check rails. Measurement and payment per joining pieces for one joint. gallerie at km 78+401.27	pcs.	10	5.000,00	50.000,00
2/2.04.05	**CRUSHED STONE, CATEGORY 1** The item includes procurement of crushed stone, its transport in FAD wagons to site and placing. Crushed stone grading shall comply with instruction for acceptance and delivery of crushed stone for track ballast on Serbian railways, and SRPS EN 13450. Measurement and payment per m^3 of compacted crushed stone placed in track. gallerie at km 78+401.27	m^3	347,00	4.200,00	1.457.400,00
				SUBTOTAL PERMANENT WAY - PROCUREMENT:	**6.868.200,00**

2/2.05.00	**PERMANENT WAY - MATERIAL HANDLING**				
2/2.05.01	**RAIL UNLOADING.** The item includes unloading of rails from wagons and their local transport to the point of track installation. Measurement for payment per tonne of delivered rails.	t	25,84	2.700,00	69.768,00
2/2.05.02	**UNLOADING OF CONCRETE SLEEPERS** The item includes unloading of concrete track and transition sleepers from wagon and transfer to and stacking on site. Measurement and payment per each unloaded sleeper.	pcs.	268	370,00	99.160,00

Item	Description	MU	Quantity	Unit price (RSD)	Total (RSD)
			A	B	AxB
2/2.05.03	**UNLOADING OF ELASTIC TRACK FASTENINGS** The Item includes unloading of elastic track fastenings from wago, transfer to and storage in site store. Measurement and payment per ton of unloaded fastenings	t	3,30	2.900,00	9.570,00

SUBTOTAL PERMANENT WAY - HANDLING:	**178.498,00**

2/2.06.00	**PERMANENT WAY - WORKS**				
2/2.06.04-2	**ASSEMBLY AND LAYING TRACK ON CONCRETE SLEEPERS, FIXING IT WITH ELASTIC TRACK FASTENINGS, RAIL TYPE 49E1.** The Item includes assembly and laying of track onto concrete sleepers, fixing elastic track fastenings, rail type 49E1. Measurement and payment per km of assembled and laid track. gallerie at km 78+401.27	km	0,13	5.360.000,00	696.800,00
2/2.06.06	**LAYING OF GUARD RAILS.** The item includes transport, handling and laying of guard rails and all required rail fastenings. Payment per km of both guard rails. gallerie at km 78+401.27	km	0,13	7.200.000,00	936.000,00
2/2.07-2	**MECHANIZED LEVELLING AND DYNAMIC STABILIZATION OF TRACK ON CONCRETE SLEEPERS, RAIL TYPE 49E1** The item includes placing of crushed stone in track, raising of track to required reference level with cant and enlargement in curves, tamping, mechanized aligning of track on the bed and on bridges. on concrete sleepers, with elastic track fastenings, rail type 49E1, formation of ballast prism and maintenance till take-over. Measurement and payment per km of finally levelled track in designed position. gallerie at km 78+401.27	km	0,13	4.300.000,00	559.000,00

Item	Description	MU	Quantity	Unit price (RSD)	Total (RSD)
			A	B	AxB
2/2.06.08-2	**ELECTRIC RESISTANCE WELDING OF 49E1 RAILS TO FORM CWR** The item includes electric resistance welding of rails in 300 m long sections, finish and testing of welds, and provision of weld quality certificates for 49E1 rail type. Measurement and payment per weld. gallerie at km 78+401.27	weld	8,00	27.000,00	216.000,00
2/2.06.09-2	**STRESS RELIEF IN RAILS 49E1 WITH FINAL WELDING.** The item includes stress relief in rails with final welding. Measurement for payment per km of track. gallerie at km 78+401.27	km	0,13	576.000,00	74.880,00
				SUB TOTAL PERMANENT WAY - WORKS:	**2.482.680,00**
2/2.07.00	**PERMANENT WAY - EQUIPMENT**				
2/2.07.01	**PROCUREMENT AND INSTALLATION OF POSTS.** The item includes the procurement and installation marks for control of CWR. Measurement for payment per piece of installed posts gallerie at km 78+401.27	pcs.	2,00	11.400,00	22.800,00
				SUBTOTAL PERMANENT WAY - TRACK EQUIPMENT:	**22.800,00**

GRAND SUMMARY

2/2.04.00	**PERMANENT WAY - PROCUREMENT**	**6.868.200,00**
2/2.05.00	**PERMANENT WAY- HANDLING**	**178.498,00**
2/2.06.00	**PERMANENT WAY-WORKS**	**2.482.680,00**
2/2.07.00	**PERMANENT WAY- EQUIPMENT**	**22.800,00**

TOTAL (RSD): **9.552.178,00**

Responsible Designer

Dragana Jokanovic, Grad.Civ.Eng.

2/2-6.1.6.4 INVESTMENT VALUE OF PERMANENT WAY FOR THE BRIDGE STRUCTURE AT KM 82+152,69 R.T. (82+153.77 L.T.)

САОБРАЋАЈНИ ИНСТИТУТ ЦИП д.о.о.
Немањина 6/IV, 11000 Београд

4-Priced bill of quantities of gallerie superstructure, 57 m long at km 82+152.69 R.T. (82+153.77 L.T.)

Novi Sad- Rumenka exit section

Item	Description	MU	Quantity	Unit price (RSD)	Total (RSD)
			A	B	AxB
2/2.04.00	**PERMANENT WAY - PROCUREMENT**				
2/2.04.01-1	**RAIL TYPE 60E1.** The item includes the procurement and delivery to site of rails type 60E1, quality R260 according to EN13674 - 1 ,min. length L=50 m. Measurement for payment per tonne of delivered rails.				
	gallerie at km82+152.69 L=56.71m	t	37,48	125.000,00	4.685.000,00
2/2.04.02-2	**CONCRETE SLEEPERS ON BRIDGES, 2.60m LONG** The item includes procurement and delivery to site of flat concrete sleepers, 2.60m long for rail type 60E1 with quard rail and rail fastening system according to SRPS EN13481-2. Measurement and payment per gallerie at km82+152.69 L=56.71m	pcs.	260	8.800,00	2.288.000,00
2/2.04.02-6	**TRANSITION CONCRETE SLEEPERS, 2.60m LONG** The item includes procurement and delivery to site of transition concrete sleepers,rail type 60 E1, L=2,60 m, Measurement and payment per piece.	ком	100	5.050,00	505.000,00
2/2.04.02-2a	**ELASTOMERIC PADS UNDER TRANSITION CONCRETE SLEEPERS, 2.60m LONG** The item includes procurement, transport and delivery of elastic rail pads to concrete sleeper factory where they will be installed. Measurement and payment per each elastomeric rail pad.				
	for concrete sleepers, 2.60m long	pcs.	112	3.000,00	336.000,00
2/2-04.02-3a	**ELASTOMERIC PADS UNDER CONCRETE SLEEPERS ON BRIDGES, 2.60m LONG** The item includes procurement, transport and delivery of elastic rail pads to concrete sleeper factory where they will be installed. Measurement and payment per each elastomeric rail pad.				

Item	Description	MU	Quantity	Unit price (RSD)	Total (RSD)
			A	B	AxB
	for concrete sleepers on bridges, 2.60m long	pcs.	72	3.000,00	216.000,00
2/2.04.03-3	**FASTENING SYSTEM FOR RUNNING RAIL AND CHECK RAIL FOR CONCRETE SLEEPERS AND RAIL TYPE 60E1.** The item includes procurement and delivery to site of rail fastenings for running rail and check rail type 60E1 for concrete sleepers according SRPS EN 13481. Measurement and payment per set/sleeper of delivered fastenings bridge at km 81+650.20, L=154m	set	260	4.600,00	1.196.000,00
2/2.04.03-9	**JOINING PIECES FOR JOINTS IN CHECK RAILS ON BRIDGES**. The item includes procurement and delivery to site of joining pieces for joints in 60E1 check rails. Measurement and payment per joining pieces for one joint.				
	bridge at km 81+650.20, L=154m	pcs.	12	5.000,00	60.000,00
2/2.04.05	**CRUSHED STONE, CATEGORY 1** The item includes procurement of crushed stone, its transport in FAD wagons to site and placing. Crushed stone grading shall comply with instruction for acceptance and delivery of crushed stone for track ballast on Serbian railways, and SRPS EN 13450. Measurement and payment per m^3 of compacted crushed stone placed in track.				
	gallerie at km82+152.69 L=56.71m	m^3	446,00	4.200,00	1.873.200,00
				SUBTOTAL PERMANENT WAY - PROCUREMENT:	**11.159.200,00**

2/2.05.00	**PERMANENT WAY - MATERIAL HANDLING**				
2/2.05.01	**RAIL UNLOADING.** The item includes unloading of rails from wagons and their local transport to the point of track installation. Measurement for payment per tonne of delivered rails.	t	37,48	2.700,00	101.196,00
2/2.05.02	**UNLOADING OF CONCRETE SLEEPERS** The item includes unloading of concrete track and transition sleepers from wagon and transfer to and stacking on site. Measurement and payment per each unloaded sleeper.	pcs.	360	370,00	133.200,00

Item	Description	MU	Quantity	Unit price (RSD)	Total (RSD)
			A	B	AxB
2/2.05.03	**UNLOADING OF ELASTIC TRACK FASTENINGS** The Item includes unloading of elastic track fastenings from wago, transfer to and storage in site store. Measurement and payment per ton of unloaded fastenings	t	3,90	2.900,00	11.310,00

SUBTOTAL PERMANENT WAY - HANDLING:	**245.706,00**

2/2.06.00	**PERMANENT WAY - WORKS**				
2/2.06.04-1	**ASSEMBLY AND LAYING TRACK ON CONCRETE SLEEPERS, FIXING IT WITH ELASTIC TRACK FASTENINGS, RAIL TYPE 60E1.** The Item includes assembly and laying of track onto concrete sleepers, fixing elastic track fastenings, rail type 60E1. Measurement and payment per km of assembled and laid track.				
	gallerie at km82+152.69 L=56.71m	km	0,16	6.105.000,00	946.397,00
2/2.06.06	**LAYING OF GUARD RAILS.** The item includes transport, handling and laying of guard rails and all required rail fastenings. Payment per km of both guard rails.				
	gallerie at km82+152.69 L=56.71m	km	0,16	7.200.000,00	1.116.143,00
2/2.06.07-1	**MECHANIZED LEVELLING AND DYNAMIC STABILIZATION OF TRACK ON CONCRETE SLEEPERS, RAIL TYPE 60E1** The item includes placing of crushed stone in track, raising of track to required reference level with cant and enlargement in curves, tamping, mechanized aligning of track on the bed and on bridges. on concrete sleepers, with elastic track fastenings, rail type 60E1, formation of ballast prism and maintenance till take-over. Measurement and payment per km of finally levelled track in designed position.				
	gallerie at km82+152.69 L=56.71m	km	0,16	5.200.000,00	832.000,00

Item	Description	MU	Quantity	Unit price (RSD)	Total (RSD)
			A	B	AxB
2/2.06.08-1	**ELECTRIC RESISTANCE WELDING OF 60E1 RAILS TO FORM CWR** The item includes electric resistance welding of rails in 300 m long sections, finish and testing of welds, and provision of weld quality certificates for 60E1 rail type. Measurement and payment per weld.				
	gallerie at km82+152.69 L=56.71m	weld	12,00	32.500,00	390.000,00
2/2.06.09-1	**STRESS RELIEF IN RAILS 60E1 WITH FINAL WELDING.** The item includes stress relief in rails with final welding. Measurement for payment per km of track.				
	gallerie at km82+152.69 L=56.71m	km	0,16	720.000,00	115.200,00
				SUB TOTAL PERMANENT WAY - WORKS:	**3.399.740,00**

2/2.07.00	**PERMANENT WAY - EQUIPMENT**				
2/2.07.01	**PROCUREMENT AND INSTALLATION OF POSTS.** The item includes the procurement and installation marks for control of CWR. Measurement for payment per piece of				
	gallerie at km82+152.69 L=56.71m	pcs.	4,00	11.400,00	45.600,00
				TOTAL PERMANENT WAY - TRACKSIDE EQUIPMENT:	**45.600,00**

GRAND SUMMARY

2/2.04.00	**PERMANENT WAY - PROCUREMENT**	**11.159.200,00**
2/2.05.00	**PERMANENT WAY- HANDLING**	**245.706,00**
2/2.06.00	**PERMANENT WAY-WORKS**	**3.399.740,00**
2/2.07.00	**PERMANENT WAY- EQUIPMENT**	**45.600,00**
	TOTAL (RSD):	**14.850.246,00**

Responsible Designer

Dragana Jokanovic, Grad.Civ.Eng.

2/2-6.1.6.5 INVESTMENT VALUE OF PERMANENT WAY FOR THE BRIDGE STRUCTURE AT KM 76+615.57R.T. (76+601.02 L.T.) И НА КМ 77+814.32 R.T. (77+807.99 L.T.), AND GALLERIES AT KM 81+283.13 R.T. (81+284.54 L.T.) AND GRAND SUMMARY

5- COST ESTIMATE FOR PERMANENT WAY WHICH WAS NOT INCLUDED IN THE DESIGN OF TRACK ALIGNMENT AND STATIONS–SUBSTRUCTURE AND PERMANENT WAY - NOVI SAD STATION, VOLUME 2/2-1.1 FOR THE BRIDGES AT KM 76+615.57 D.T. (76+601.02 L.T.) AND KM 77+814.32 R.T. (77+807.99 L.T.), AND FOR THE GALLERY AT KM 81+283.13 R.T.(81+284.54 L.T.)

Item	Description	MU	Quantity	Unit price (RSD)	Total (RSD)
			A	B	AxB
2/2.04.00	**PERMANENT WAY - PROCUREMENT**				
2/2.04.02-2a	**FLAT CONCRETE SLEEPERS - FOR ZONE BETWEEN THE SWITCH AND THE BRIDGE, 2.60m LONG** The item includes procurement and delivery to site of concrete sleepers, 2.60m long for 60E1 rail with base plate and rubber pads, according to SRPS EN13481-2. Measurement and payment per piece. bridge at km 76+615.57	ком	141	6.000,00	846.000,00
2/2.04.02-6	**TRANSITION CONCRETE SLEEPERS, 2.60m LONG** The item includes procurement and delivery to site of transition concrete sleepers,rail type 60 E1, L=2,60 m, Measurement and payment per piece. bridge at km 76+615.57 bridge at km 77+814.32 bridge at km 81+283.13	ком ком ком	25 200 100	5.050,00 5.050,00 5.050,00	126.250,00 1.010.000,00 505.000,00
2/2.04.02-2a	**ELASTOMERIC PADS UNDER TRANSITION CONCRETE SLEEPERS , 2.60m LONG** The item includes procurement, transport and delivery of elastic rail pads to concrete sleeper factory where they will be installed. Measurement and payment per each elastomeric rail pad. for concrete sleepers, 2.60m long bridge at km 76+615.5 gallery at km 81+283.13	 pcs. pcs.	 8 100	 3.000,00 3.000,00	 24.000,00 300.000,00

2/2-04.02-3a	**ELASTOMERIC PADS UNDER CONCRETE SLEEPERS ON BRIDGES, 2.60m LONG** The item includes procurement, transport and delivery of elastic rail pads to concrete sleeper factory where they will be installed. Measurement and payment per each elastomeric rail pad. for concrete sleepers on bridges, 2.60m long				
	bridge at km 76+615.5	pcs.	82	3.000,00	246.000,00
	bridge at km 77+814.32	pcs.	144	3.000,00	432.000,00
	gallery at km 81+283.13	pcs.	72	3.000,00	216.000,00
2/2-04.02-4a	**ELASTOMERIC PADS UNDER FLAT CONCRETE SLEEPERS - FOR ZONE BETWEEN THE SWITCH AND THE BRIDGE, 2.60m LONG** The item includes procurement, transport and delivery of elastic rail pads to concrete sleeper factory where they will be installed. Measurement and payment per each elastomeric rail pad. for concrete sleepers on bridges,				
	bridge at km 76+615.5	pcs.	25	3.000,00	75.000,00
2/2.04.03-3a	**FASTENING SYSTEM FOR RUNNING RAIL FOR FLAT CONCRETE SLEEPERS - FOR ZONE BETWEEN THE SWITCH AND THE BRIDGE AND RAIL TYPE 60E1** The item includes procurement and delivery to site of rail fastenings for running rail and check rail type 60E1 for concrete sleepers according SRPS EN 13481. Measurement and payment per set/sleeper of delivered fastenings	сет	141	2.300,00	324.300,00
				SUBTOTAL PERMANENT WAY - PROCUREMENT:	**4.104.550,00**

2/2.05.00	**PERMANENT WAY - MATERIAL HANDLING**				
2/2.05.02	**UNLOADING OF CONCRETE SLEEPERS** The item includes unloading of concrete track and transition sleepers from wagon and transfer to and stacking on site. Measurement and payment per each unloaded sleeper.	ком	466	370,00	172.420,00

2/2.05.03	**UNLOADING OF ELASTIC TRACK FASTENINGS** The Item includes unloading of elastic track fastenings from wago, transfer to and storage in site store. Measurement and payment per ton of unloaded fastenings	t	1,06	2.900,00	3.074,00

SUBTOTAL PERMANENT WAY - HANDLING:	**175.494,00**

	COST ESTIMATE FOR PERMANENT WAY WHICH WAS NOT INCLUDED IN THE DESIGN OF TRACK ALIGNMENT AND STATIONS – SUBSTRUCTURE AND PERMANENT WAY - NOVI SAD STATION, VOLUME 2/2-1.1 FOR THE BRIDGES AT KM 76+615.57 D.T. (76+601.02 L.T.) AND KM 77+814.32 R.T. (77+807.99 L.T.), AND FOR THE GALLERY AT KM 81+283.13 R.T. (81+284.54 L.T.)	**4.280.044,00**

GRAND SUMMARY

2/2-6.1.6.1	**BRIDGE AT KM 81+650.20 R.T. (81+644.83 L.T.)**	**44.738.594,00**
2/2-6.1.6.2	**BRIDGE AT 0+751.01 R.T. (0+796.33 L.T.)**	**42.655.753,00**
2/2-6.1.6.3.	**GALLERY AT KM 78+401,27 R.T. (78+377.03L.T.)**	**9.552.178,00**
2/2-6.1.6.4	**GALLERY ATKM 82+152,69 R.T. (82+153.77 L.T.)**	**14.850.246,00**
2/2-6.1.6.5	**COST ESTIMATE FOR PERMANENT WAY WHICH WAS NOT INCLUDED IN THE DESIGN OF TRACK ALIGNMENT AND STATIONS – SUBSTRUCTURE AND PERMANENT WAY - NOVI SAD STATION, VOLUME 2/2-1.1 FOR THE BRIDGES AT KM 76+615.57 D.T. (76+601.02 L.T.) AND KM 77+814.32 R.T. (77+807.99 L.T.), AND FOR THE GALLERY AT KM 81+283.13 R.T. (81+284.54 L.T.)**	**4.280.044,00**

TOTAL (RSD): **116.076.815,00**

Responsible Designer

Dragana Jokanovic, Grad.Civ.Eng.

2/2-6.1.6.6 CALCULATIONS INTERACTION VEHICLE/ TRACK/BRIDGE

2/2-6.1.6.6.1 CALCULATIONS OF VEHICLE/ TRACK/BRIDGE INTERACTION FOR BRIDGE AT KM 76+615.57 R.T. (76+601.02 L.T.)

CONTENT

1.1 Textual documentation

1.1.1 Technical report

1.1.1.1 Results of the calculation of the track-bridge interaction
1.1.1.2 Results of checking the stability of the track in the horizontal plane on the bridge
1.1.1.3 Results of checking the size of the rail gap on the bridge
1.1.1.4 Technical measures to ensure safety in case of derailment of the vehicle on the bridge

1.2 Numerical documentation

1.2.1 Static calculation

1.2.1.1 Input calculation parameters of the load
1.2.1.2 Input calculation parameters of the track
1.2.1.3 Input calculation parameters of the bridge
1.2.1.4 Calculation model of track-bridge interaction
1.2.1.5 Calculation of track-bridge interaction for summer climatic conditions
1.2.1.6 Calculation of track-bridge interaction for winter climatic conditions
1.2.1.7 Track stability in the horizontal plane on the bridge in summer climatic conditions
1.2.1.8 Size of the rail gap on the bridge in winter climatic conditions

1.1 Textual documentation

1.1.1 Technical report

The calculation of the track-bridge interaction for the purpose of arranging the railway superstructure on the bridge at km 76+601.02 was performed in accordance with the requirements of the Technical Specifications of Interoperability for Infrastructure Subsystem (INF TSI).

Input design load parameters are harmonized with: Technical Specifications of Interoperability for Infrastructure Subsystem, as well as Serbian standards SRPS EN 1991-1-5, SRPS EN 1991-1-5/NA, SRPS EN 1991-2, SRPS EN 1991-2/NA.

In this sense, considered the following load due to:

- relevant temperature changes in the axis of the bridge deck and continuously welded rails,
- vertical load of the vehicle in accordance with the load scheme LM 71, SW/0, SW/2.
- horizontal load due to acceleration and/or braking of the vehicle.

All input calculation data in accordance with the bridge structure, railway superstructure, as well as railway vehicles are shown in Chapters 1.2.1.1, 1.2.1.2 and 1.2.1.3. In accordance with design speed of 100 km/h, a static calculation of the track-bridge interaction was performed. The calculation was performed using an integral model of track and bridge structures, with consideration of:

- bridge parameters: bridge disposition (static system, span, expansion length), geometrical characteristics of the bridge superstructure, stiffness and arrangement of bearings,
- track parameters: rail cross-section and rail steel quality, resistance to longitudinal displacement of unloaded and loaded track, taking into account bilinear behavior,
- load parameters: temperature change in the bridge superstructure, temperature changes in the continuously welded rails, acceleration/braking of vehicles, displacement and rotation of the ends of the bridge superstructure due to traffic load.

The connection between the track and the bridge superstructure was modeled using elastic connections with bilinear behavior. The horizontal stiffness of the supporting elements is defined in the model based on UIC 774-3 recommendations and standard SRPS EN 1991-2. In this way, the influences in the rails are obtained, which are relevant for comparison with the allowed additional stresses, proving the stability of the track in the horizontal plane for maximum summer temperatures, as well as gap size due to rail cracking for maximum winter temperatures. The calculation model takes into account the track with continuously welded rails at the length of the bridge and 300 m before and after the bridge, which corresponds to the maximum influential braking length of the vehicle. The layout of the calculation model is shown in Figures 9-11. A detailed description of the model characteristics is presented in Chapter 1.2.1.4.

1.1.1.1 Results of the calculation of the track-bridge interaction

Horizontal reactions on one (out of a total of five on the edge structure of the bridge, ie. of a total of four on the middle bridge structure) fix bridge bearing on one (out of a total of two) middle pier due to the track-bridge interaction:

Edge structure of bridge (left track/freight track):

Type of load	Summer climatic conditions	Winter climatic conditions
Temperature change in axis of the bridge and continuously welded rails	**±139,32 kN**	**±140,18 kN**
Acceleration of train	**-58,66 kN**	**-46,92 kN**
Vertical load of train	**±9,44 kN**	**±9,52 kN**
Note 1: The positive direction of the reaction corresponds to the direction of growth of the chainage. Note 2: The influence of temperature force, train acceleration force and corresponding vertical train load force or temperature force, train braking force and corresponding vertical train load force are taken for dimensioning of the bridge bearing.		

Middle structure of bridge (right track):

Type of load	Summer climatic conditions	Winter climatic conditions
Temperature change in axis of the bridge and continuously welded rails	**±171,45 kN**	**±171,13 kN**
Braking of train	**-54,33 kN**	**-42,85 kN**

Vertical load of train	**±11,80 kN**	**±11,90 kN**
Note 1: The positive direction of the reaction corresponds to the direction of growth of the chainage. Note 2: The influence of temperature force, train acceleration force and corresponding vertical train load force or temperature force, train braking force and corresponding vertical train load force are taken for dimensioning of the bridge bearing.		

Maximum additional compressive and tensile stresses in continuously welded rails:

Type of load	**Left track/Freight track**	**Right track**
Summer climatic conditions		
Temperature change in axis of the bridge and continuously welded rails	-8,06 MPa	-7,23 MPa
Acceleration of train/ Braking of train	-48,77 MPa	-45,37 MPa
Vertical load from the train	0,00 MPa	0,00 MPa
Total additional compressive/tensile stresses in the relevant sections of the continuously welded rail	**-56,83 MPa ≤ -72 MPa**	**-52,60 MPa ≤ -72 MPa**
Winter climatic conditions		
Temperature change in axis of the bridge and continuously welded rails	+15,94 MPa	+14,38 MPa
Acceleration of train/ Braking of train	+58,45 MPa	+57,20 MPa
Vertical load from the train	+1,16 MPa	+1,20 MPa
Total additional compressive/tensile stresses in the relevant sections of the continuously welded rail	**+75,55 MPa ≤ +92 MPa**	**+72,78 MPa ≤ +92 MPa**
Note 1: Pressure stresses with sign (-), tensile stresses with sign (+)		

Maximum absolute and relative displacements of the track and the bridge superstructure:

Edge structure of bridge (left track/freight track):

Type of displacement	**Summer climatic conditions**	**Winter climatic conditions**
Absolute horizontal displacement of the bridge superstructure due to acceleration/braking of the train	**4,04 mm ≤ 5 mm**	**4,01 mm ≤ 5 mm**
Relative horizontal displacement between the rail and the bridge superstructure due to acceleration/braking of the train	**1,48 mm ≤ 4 mm (acceleration)**	**1,50 mm ≤ 4 mm (acceleration)**
Horizontal displacement due to rotating of the bridge ends under the vertical load from the train	**0,04 mm ≤ 8mm**	**0,04 mm ≤ 8mm**

Middle structure of bridge (right track):

Type of displacement	**Summer climatic conditions**	**Winter climatic conditions**
Absolute horizontal displacement of the bridge superstructure due to acceleration/braking of the train	**3,97 mm ≤ 5 mm**	**4,04 mm ≤ 5 mm**
Relative horizontal displacement between the rail and the bridge superstructure due to acceleration/braking of the train	**1,58 mm ≤ 4 mm (braking)**	**1,60 mm ≤ 4 mm (braking)**
Horizontal displacement due to rotating of the bridge ends under the vertical load from the train	**0,04 mm ≤ 8mm**	**0,04 mm ≤ 8mm**

1.1.1.2 Results of checking the stability of the track in the horizontal plane on the bridge

Input parameters for checking the stability of the track in the horizontal plane on the bridge at extreme summer temperatures in the rails and the bridge superstructure were adopted in accordance with Chapter 1.2.1.7 and based on the results of the calculation of the track-bridge interaction.

Checking the stability of the track in the horizontal plane was carried out for the maximum value of the pressure force in the track on the bridge -1697970 N.

1.1.1.3 Results of checking the size of the rail gap on the bridge

The calculation was performed under the assumption that the maximum longitudinal resistance during elastic displacement of the rail through the system of elastic rail fastening is 30 kN/m, which corresponds to the force of longitudinal resistance 9 kN.

The calculated value of the rail gap in winter conditions is approximately 38,26 mm.

1.1.1.4 Technical measures to ensure safety in case of derailment of the vehicle on the bridge

- The guard rails, to keep trains on the track in the event of derailment, must be installed, as they can provide safety at speeds up to 160 km/h. The role of the guard rails is to keep the vehicle on track if it derailment on the bridge. In that way, the structure of the bridge is protected from damage and other negative consequences of derailment are reduced (for example. the vehicle fell off the bridge after derailment). Guard rails are mounted on sleepers with a flat upper surface. Guard rails are extended by 10 m to the embankments before and after the bridge and are connected in the middle of the track. It is necessary to ensure that the curb upper edge of the concrete bridge deck is 25 cm above the upper edge of the sleeper.

1.2 Numerical documentation

1.2.1 Static calculation

1.2.1.1 Input calculation parameters of the load

Input calculation parameters of load are harmonized with: Technical specifications of interoperability for subsystem of infrastructure, as well as Serbian standards SRPS EN 1991-1-5, SRPS EN 1991-1-5/NA, SRPS EN 1991-2, SRPS EN 1991-2/NA.

Temperature:

- temperature change in continuously welded rails in summer climatic conditions: +42,5 K,
- temperature change in continuously welded rails in winter climatic conditions: -52,5 K,
- temperature change in the bridge superstructure in summer climatic conditions: +35 K,
- temperature change in the bridge superstructure in winter climatic conditions: -35 K.

Vertical load from the train:

- LM71

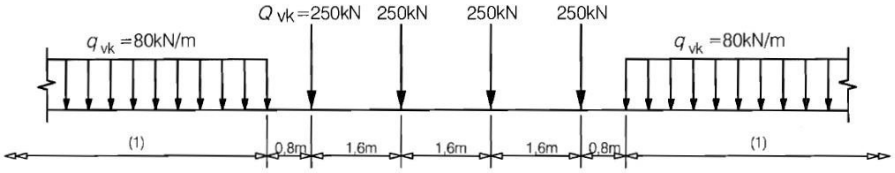
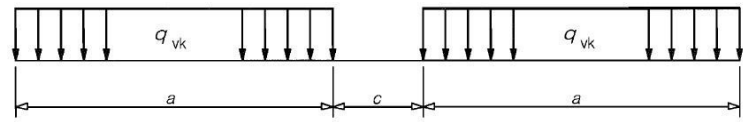


Fig. 2: Load model LM71 (α=1,21)

- SW/0, SW/2



Load Model	q_{vk} [kN/m]	a [m]	c [m]
SW/0	133	15,0	5,3
SW/2	150	25,0	7,0

Fig. 3: Load model SW/0, SW/2 (α=1,21 for SW/0)

Horizontal load from train acceleration/braking LM71, SW/0, SW/2:

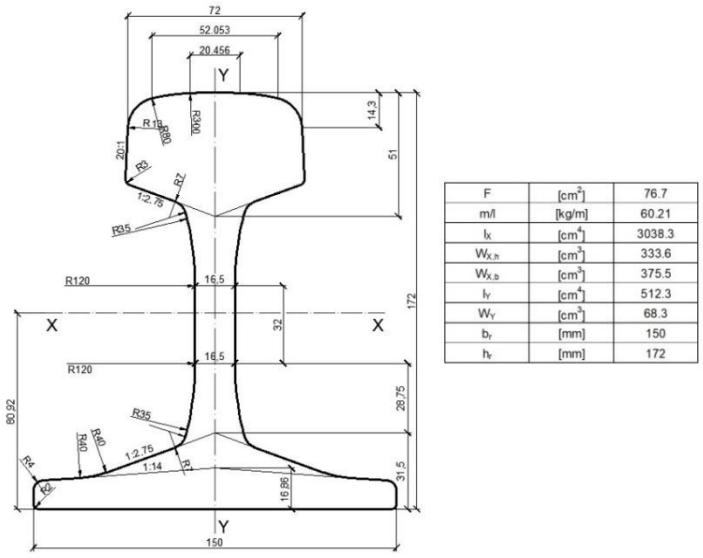
- train acceleration force 33 kN/m (≤1000 kN) for LM71, SW/0, SW/2 (α=1,21 for LM71, SW/0),
- train braking force 20 kN/m (≤6000 kN) for LM71, SW/0 (α=1,21),
- train braking force 35 kN/m for SW/2.

1.2.1.2 Input calculation parameters of the track

The input calculation parameters of the track are harmonized with: Serbian standards SRPS EN 13146-1, SRPS EN 13230 - parts 1 and 2, SRPS EN 13231, SRPS EN 13450, SRPS EN 13481 - parts 1 and 2, SRPS EN 13674-1, SRPS EN 1991-2, Law on the Safety of Railway Transport and Interoperability, as well as the Rulebook on Technical Conditions and Maintenance of the Railway Superstructure.

Rail

- rail cross-section 60E1 (tensile strength of steel 900 N/mm^2) in accordance with SRPS EN 13674-1,
- Young's modulus of elasticity of rail steel E=210 GPa,
- allowable additional tensile stress in rail foot 92 MPa in accordance with SRPS EN 1991-2,
- permissible additional pressure stress in rail 72 MPa in accordance with SRPS EN 1991-2,
- thermal expansion coefficient of rail steel α=1,15x10^{-5} 1/K.



F	[cm^2]	76.7
m/l	[kg/m]	60.21
I_X	[cm^4]	3038.3
$W_{X,h}$	[cm^3]	333.6
$W_{X,b}$	[cm^3]	375.5
I_Y	[cm^4]	512.3
W_Y	[cm^3]	68.3
b_r	[mm]	150
h_r	[mm]	172

Fig. 4: Rail cross-section 60E1 with geometric characteristics

Elastic rail fastening systems

For concrete sleepers in accordance with a series of Serbian standards SRPS EN 13481 - parts 1 and 2 and SRPS EN 13146-1.

- minimum longitudinal resistance to rail displacement ≥ 7 kN (calculated with 9 kN) in accordance with SRPS EN 13674-1,

Mono block prestressed concrete sleepers with a flat top surface

In accordance with a series of Serbian standards SRPS EN 13481-2 and SRPS EN 13230 - parts 1 and 2.

- minimum sleeper mass 281 kg without rail fastening,
- sleeper length 260 cm,
- longitudinal axial distance between sleepers 60 cm,
- minimum active backing surface of sleeper on ballast 0,57 m^2.

Ballast prism of gravel

In accordance with a series of Serbian standards SRPS EN 13450 with the dimensions of the ballast prism according to SRPS EN 13231.

- the minimum thickness of the ballast prism on the bridge below the lower edge of the sleeper in the cross-section below the rail 35 cm,
- width of the shoulder part of the ballast prism on the concrete deck of the bridge > 50 cm,
- resistance of the ballast prism to the longitudinal displacement of the unloaded track k=20 kN/m in accordance with SRPS EN 1991-2,
- resistance of the ballast prism to the longitudinal displacement of the loaded track k=60 kN/m in accordance with SRPS EN 1991-2.

1.2.1.3 Input calculation parameters of the bridge

The input design parameters of the bridge are defined in accordance with the characteristics of the bridge structure.

- the bridge is a continuous girder static system with spans 11.60 m + 17.40 m + 11.60 m,
- the bridge superstructure consists of three mutually dilated composite bridge structures,
- steel I profiles are constructed from steel grade S355,
- concrete deck is made of concrete class C35/45,
- the support of bridge superstructure is done over 40 bearings, 6 on each abutment, and 14 on each middle pier,
- the required minimum longitudinal (horizontal) stiffness of the supports of bridge superstructure due to acceleration/braking train is ≥ 230000 kN/m,
- the expansion length of the bridge is L_T=20.30 m,
- bridge is straight,
- on the bridge there are a three track of railway designed for speed V_p=100 km/h,
- the maximum permissible longitudinal relative displacement between the continuously welded rail and the bridge superstructure due to acceleration/braking of the train is ≤ 4 mm,

- the maximum permissible longitudinal absolute displacement of the bridge superstructure due to acceleration/braking of the train is ≤ 5 mm,
- the maximum permissible longitudinal displacement of the bridge superstructure due to the rotation of the ends of the bridge superstructure under the vertical load from the train is ≤ 8 mm.

Longitudinal section

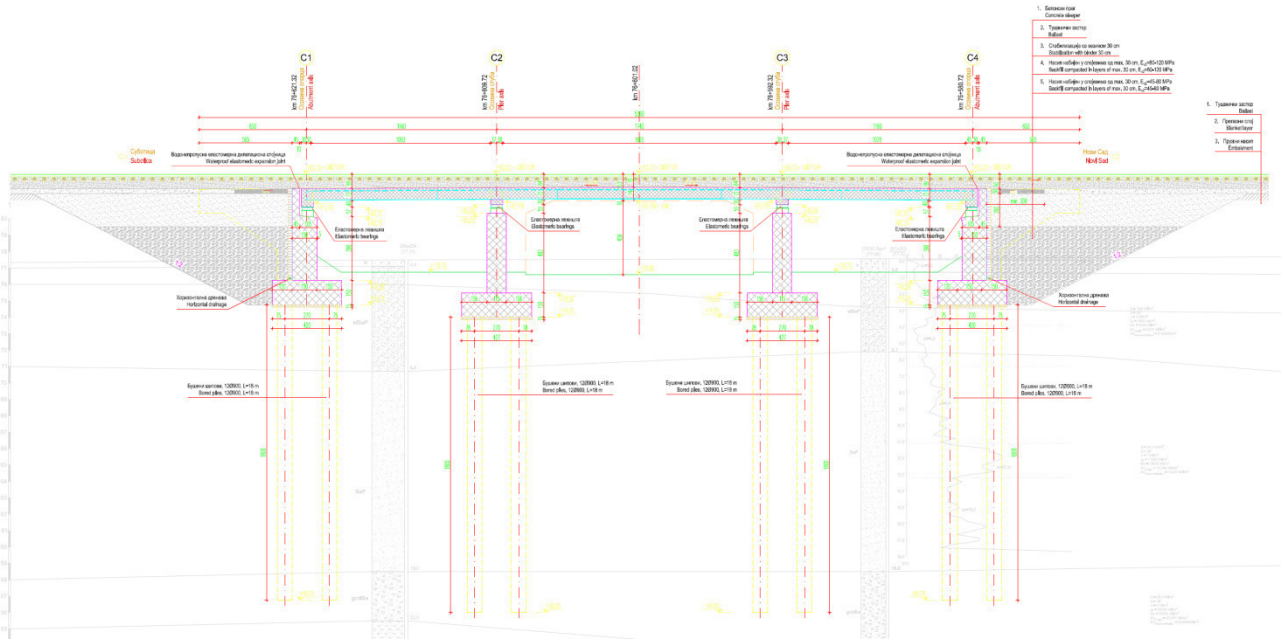


Fig. 5: Longitudinal section of the bridge on km 76+601.02

Cross-section

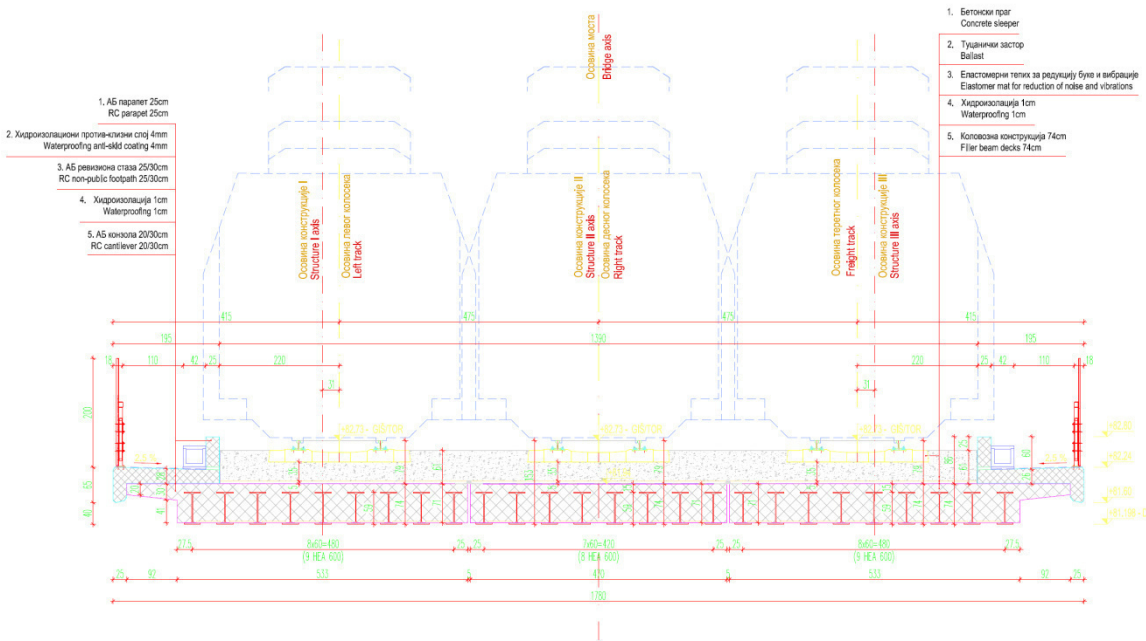


Fig. 6: Cross-section of the bridge on km 76+601.02

Bearing scheme

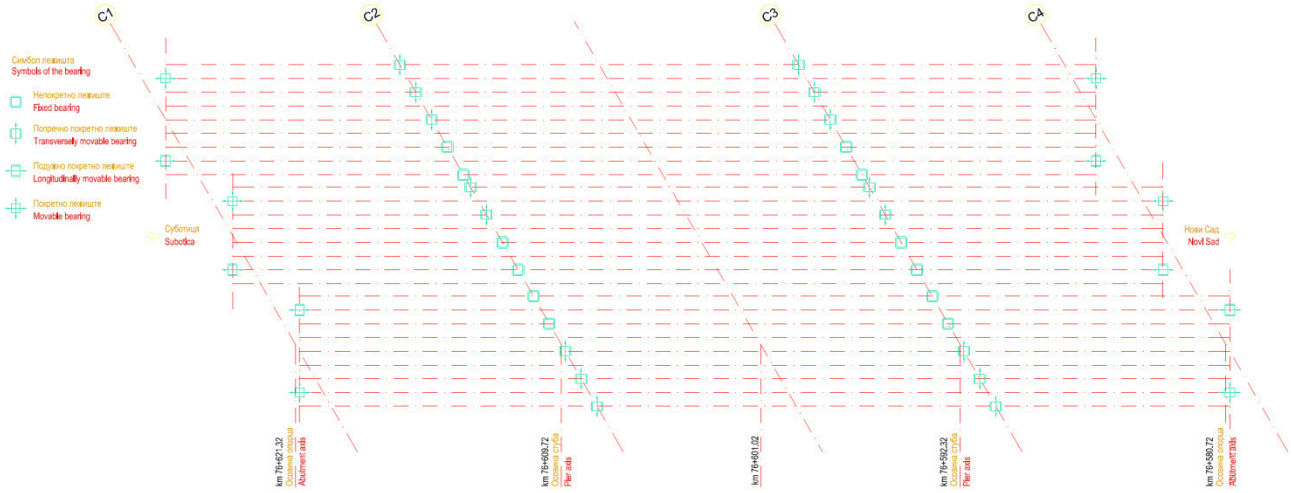
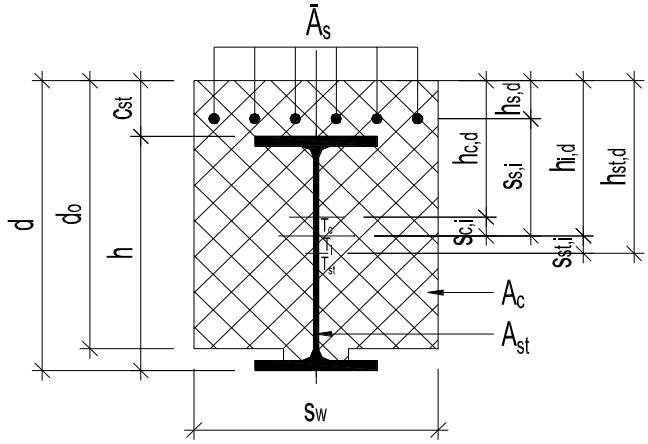


Fig. 7: Bearing scheme of bridge on km 76+601.02

Geometrical characteristics of elements bridge superstructure



$$h_{i,d} = \frac{(n-1)\cdot(A_{st}\cdot h_{st,d} + \bar{A}_s \cdot h_{s,d}) + A_c \cdot d_0/2}{(n-1)\cdot(A_{st} + \bar{A}_s) + A_c}$$

set	d [cm]	A_{st} [cm^2]	$I_{t,st}$ [cm^4]	I_{st} [cm^4]	h [cm]	$h_{st,d}$ [cm]	d_o [cm]	s_w [cm]	A_c [cm^2]	I_c [cm^4]	c_{st} [cm]	$h_{c,d}$ [cm]	$\bar{A}_s$ [cm^2]	$h_{s,d}$ [cm]
1	73	226	352	141208	59	43.5	67.5	60	3947	1541636	14	34.3	0	0
2	73	226	352	141208	59	43.5	67.5	60	3947	1541636	14	34.3	19.64	7.95

	Kratkotrajna opterećenja		n_i= 6			
set	A_i [cm^2]	$h_{i,d}^0$ [cm]	$s_{st,i}$ [cm]	$s_{c,i}$ [cm]	$s_{s,i}$ [cm]	I_i [cm^4]
1	884	36.38	-7.12	2.04	0.00	412338
2	903	35.84	-7.66	1.50	27.89	413682

	Dugotrajna opterećenja		n_v= 18			
set	A_i [cm^2]	$h_{i,d}^0$ [cm]	$s_{st,i}$ [cm]	$s_{c,i}$ [cm]	$s_{s,i}$ [cm]	I_i [cm^4]
1	445	38.86	-4.64	4.52	0.00	236197
2	465	37.59	-5.91	3.25	29.64	237962

Material characteristics of the elements bridge superstructure

Steel I profile are of steel grade S355 with the following characteristics:

Steel grade S355:

- $E=2,1x10^{8}$ kN/m^2
- v=0,3
- $\alpha=1,2x10^{-5}$ 1/C
- $\rho=76,98$ kN/m^3

Concrete deck is made of concrete class C35/45 with the following characteristics:

Concrete class C35/45:

- $E= 3,4077x10^{7}$ kN/m^2
- v=0,2
- $\alpha=1,0x10^{-5}$ 1/C
- $\rho=23,54$ kN/m^3

Steel reinforcement in the concrete is grade B500B:

Steel reinforcement grade B500B:

- $E=2,1x10^{8}$ kN/m^2
- v=0,3
- $\alpha=1,2x10^{-5}$ 1/C
- $\rho=76,98$ kN/m^3

1.2.1.4 Calculation model of track-bridge interaction

Based on the calculation of the track-bridge interaction, the influences are obtained in the following form:

- longitudinal forces in supports (reactions of fixed supports),
- additional stresses in rails,
- absolute and relative displacements of the rails and the bridge superstructure.

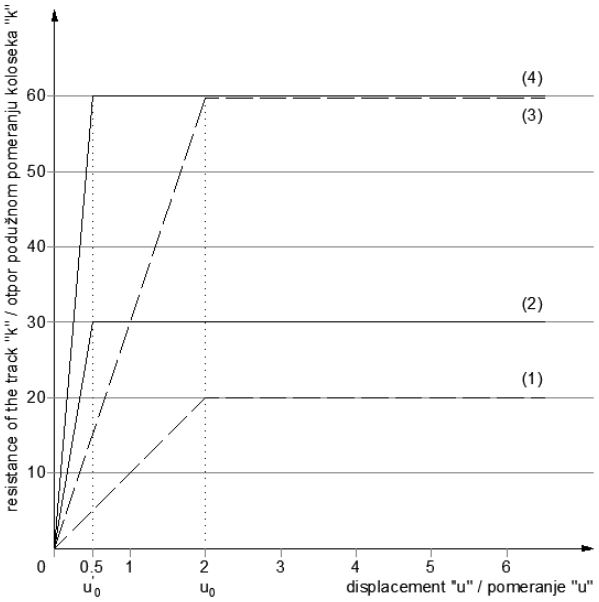
Influences due to interaction are determined iteratively, by a series of nonlinear simulations, in order to determine the behavior of the track-bridge system, due to temperature changes in the bridge superstructure, vertical load from the train and longitudinal forces due to train acceleration/braking.

The calculation of the track-bridge interaction is carried out using an integral model of track and bridge structure taking into account:

- bridge parameters: bridge disposition (static system, spans, expansion lengths), geometrical characteristics of the bridge superstructure, stiffness of structure and arrangement of supports,
- track parameters: rail cross-section and rail steel quality, resistance to longitudinal displacement of loaded and unloaded track, taking into account the bilinear behavior of the track-bridge connection,
- load parameters: temperature changes in the bridge superstructure and rails, acceleration and braking of the train, displacement and rotating the ends of the bridge super structure due to traffic load.

The connection between the track elements and the bridge superstructure elements was modeled by means of elastic connections with bilinear behavior in accordance with the Serbian standard SRPS EN 1991-2 (Figure 8).

In the model adopted horizontal stiffness of the fixed support, which corresponds to the real displacement of the bridge superstructure due to acceleration/braking the train. In this way, the influences in the rails are obtained, which are relevant for the analysis of the allowed additional stresses and track stability in the horizontal plane at maximum summer temperature, as well as the size of the gap when the rail cracks at maximum winter temperature. The calculation model takes into account the track with continuously welded rails at a length of 300 m in before and after the bridge, which corresponds to the maximum influential length of train braking.



(1) - resistance of sleeper in ballast (unloaded track)
otpor podužnom pomeranju praga kroz zastor (neopterećen kolosek)

(2) - resistance of rail in sleeper (unloaded track) (frozen ballast or track without ballast)
otpor podužnom pomeranju šine u odnosu na prag (neopterećen kolosek) (smrznuti zastor ili kolosek na čvrstoj podlozi)

(3) - resistance of sleeper in ballast (loaded track)
otpor podužnom pomeranju praga kroz zastor (opterećen kolosek)

(4) - resistance of rail in sleeper (loaded track) (frozen ballast or track without ballast)
otpor podužnom pomeranju šine u odnosu na prag (opterećen kolosek) (smrznuti zastor ili kolosek na čvrstoj podlozi)

u'_0 - ultimate relative displacement of the rail to the sleeper
granično relativno pomeranje šine u odnosu na prag

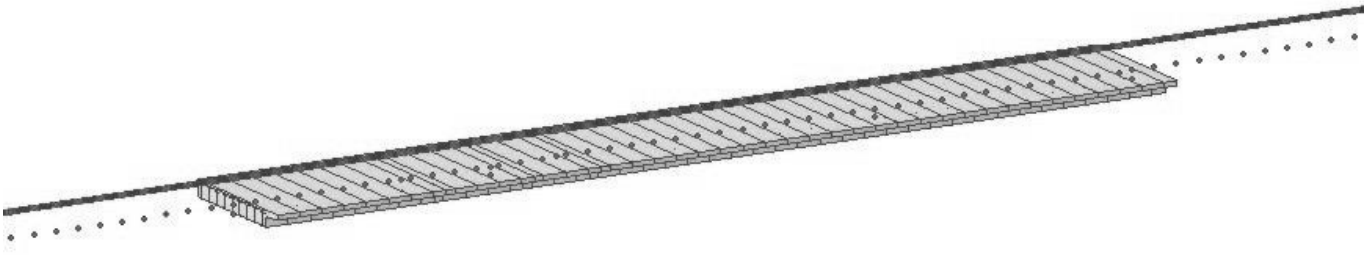
u_0 - ultimative relative displacement of the sleeper in the ballast
granično relativno pomeranje praga u odnosu na zastor

Note: / Napomena:
rail profile 60E1, concrete sleepers B70 at a distance of 60 cm and longitudinal resistance of the rail in the track 2x9 kN, minimum thickness of the compacted ballast below the sleeper is 30 cm.
šine 60E1, betonski pragovi B70 na razmaku 60 cm i podužni otpor šina u koloseku 2x9 kN, minimalna debljina zbijenog zastora ispod praga 30 cm.

Fig. 8: Longitudinal displacement resistance of track/rail

View of calculation model

Edge structure of bridge (left track/freight track)



Middle structure of bridge (right track)

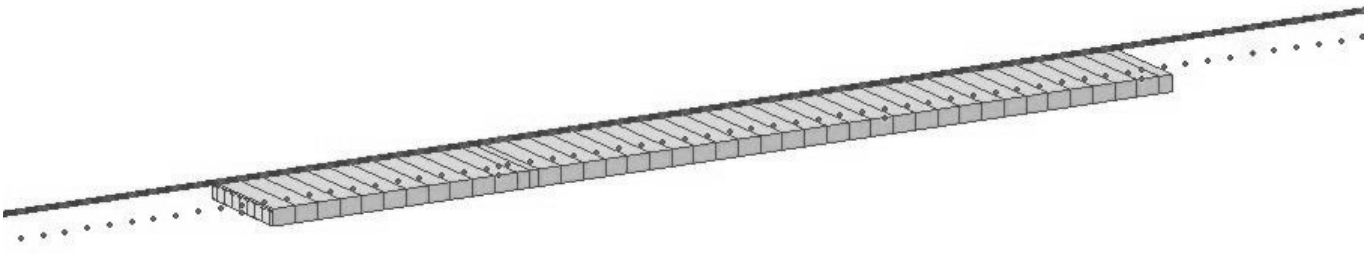


Fig. 9: View of calculation model

Longitudinal section of the calculation model

Edge structure of bridge (left track/freight track)

Middle structure of bridge (right track)

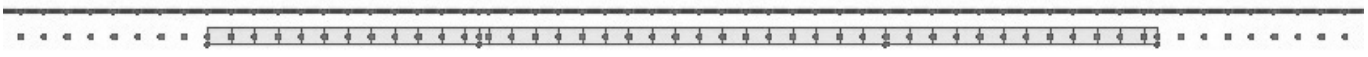
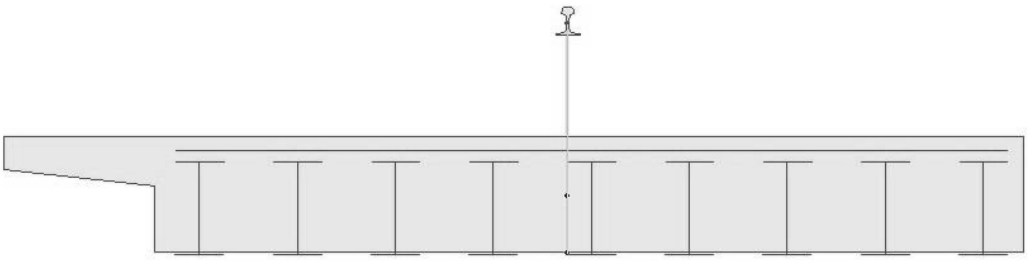


Fig. 10: Longitudinal section of the calculation model

Cross-section of calculation model

Edge structure of bridge (left track/freight track)



Middle structure of bridge (right track)

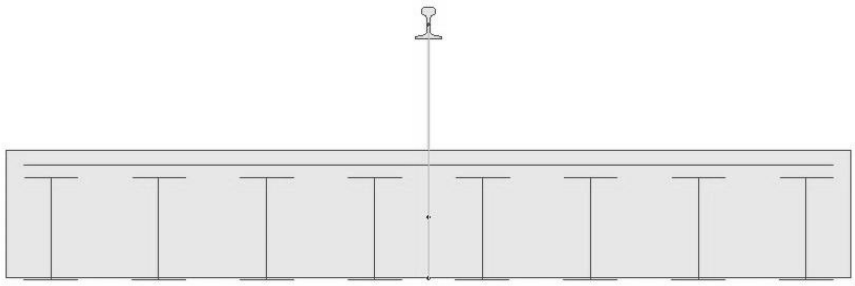
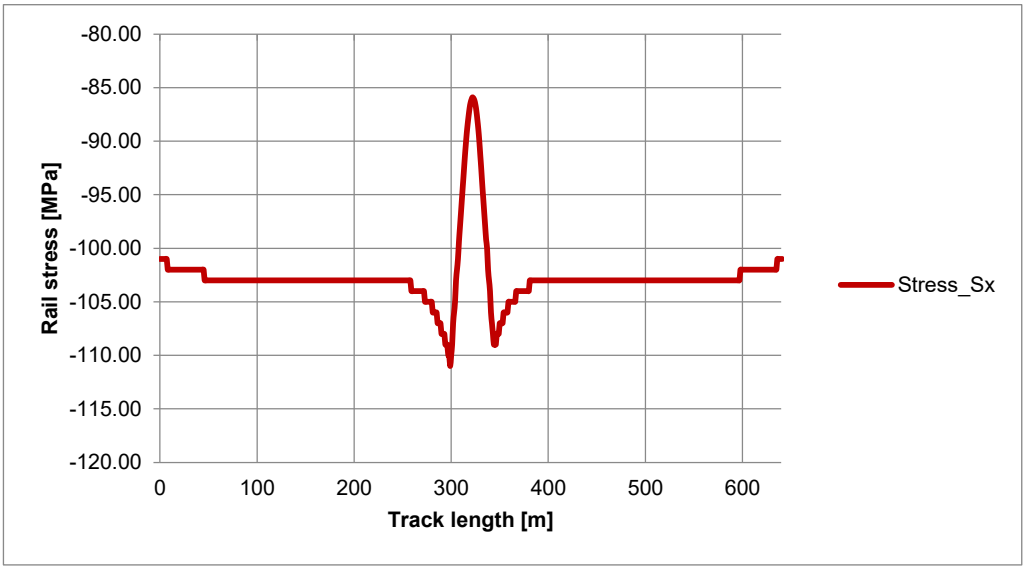


Fig. 11: Cross-section of the calculation model with elastic connections with bilinear behavior between the track and the bridge superstructure

1.2.1.5 Calculation of track-bridge interaction for summer climatic conditions

1) Rail stress due to temperature change in bridge superstructure and continuously welded rails

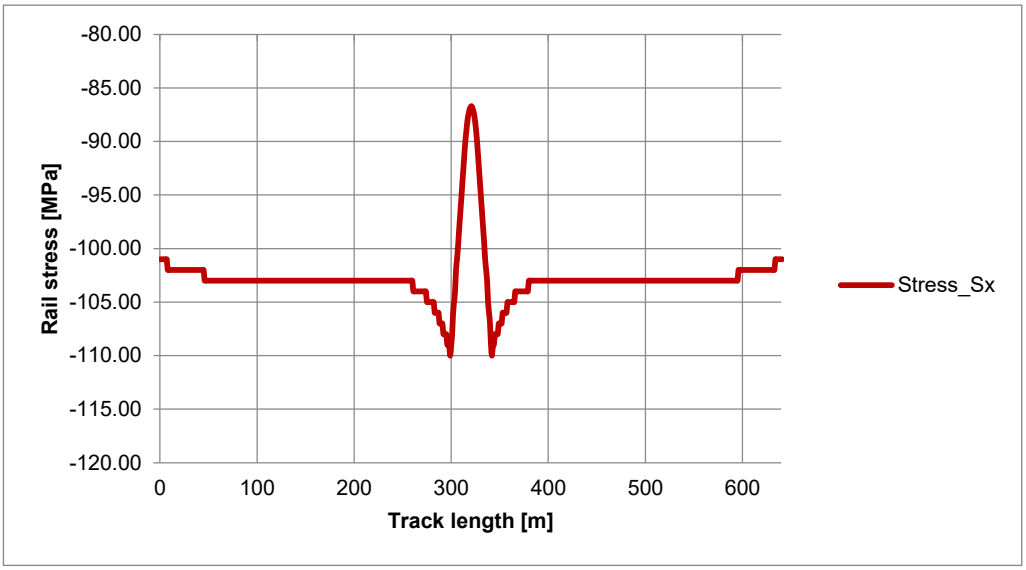
Left track/Freight track



Maximum pressure stress in rail = **-8,06 MPa**

Maximum tensile stress in rail = **0,00 MPa**

Right track

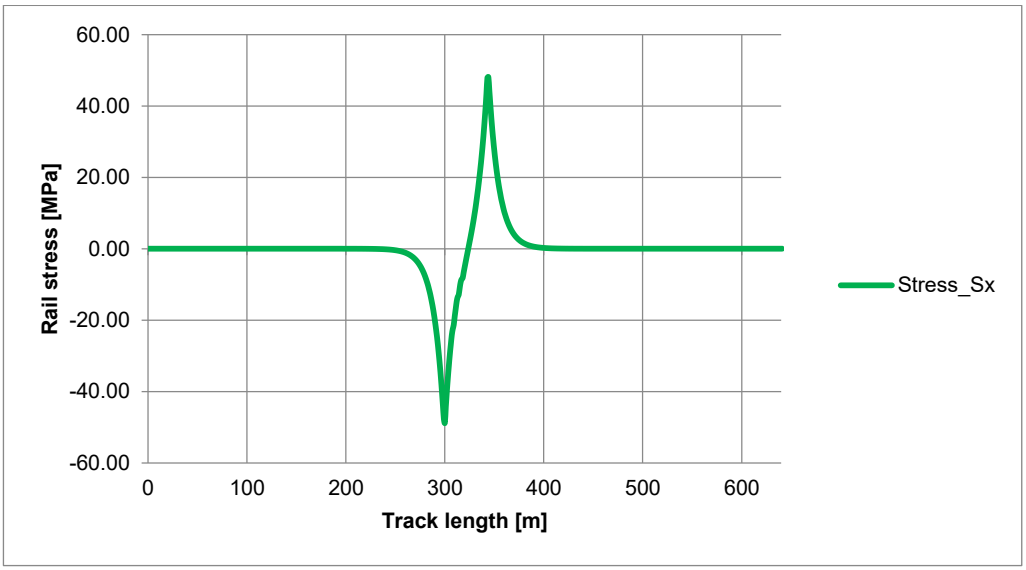


Maximum pressure stress in rail = **-7,23 MPa**

Maximum tensile stress in rail = **0,00 MPa**

2) Rail stress due to train acceleration/braking

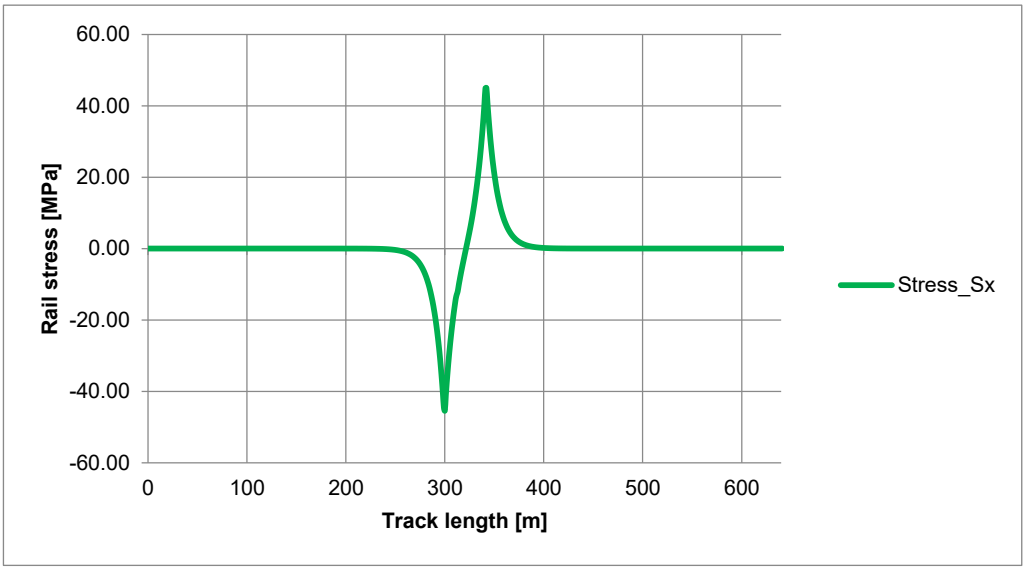
Left track/Freight track (train acceleration)



Maximum pressure stress in rail = **-48,77 MPa**

Maximum tensile stress in rail = **0,00 MPa**

Right track (train braking)

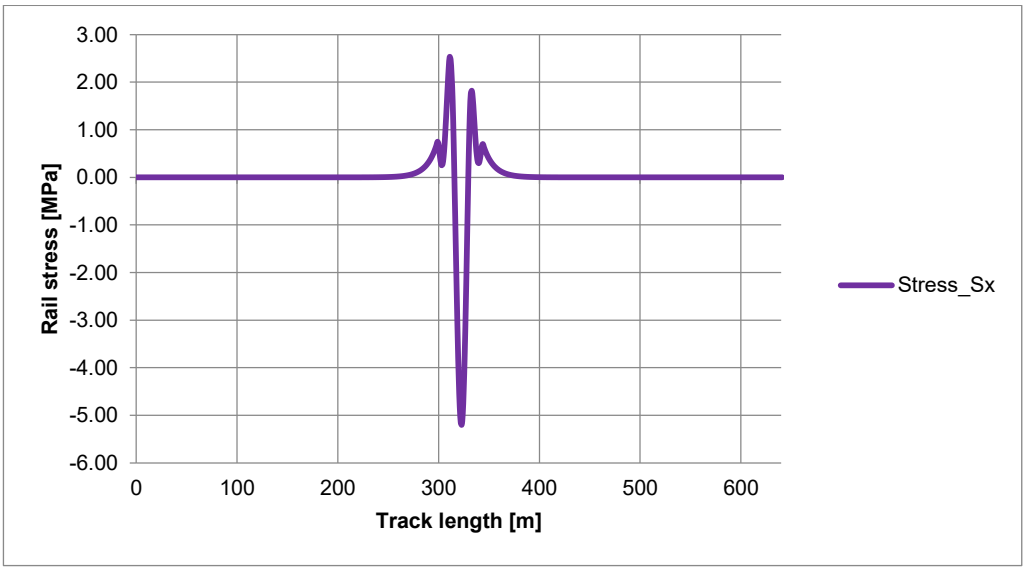


Maximum pressure stress in rail = **-45,37 MPa**

Maximum tensile stress in rail = **0,00 MPa**

3) Rail stress due to vertical bending under train

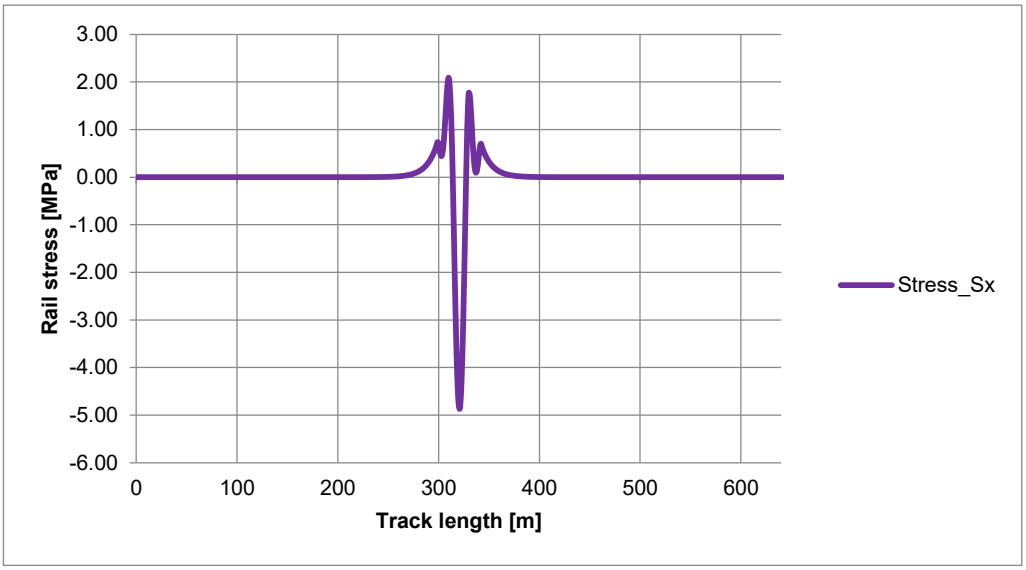
Left track/Freight track



Maximum pressure stress in rail = **0,00 MPa**

Maximum tensile stress in rail = **+0,82 MPa**

Right track



Maximum pressure stress in rail = **0,00 MPa**

Maximum tensile stress in rail = **+0,83 MPa**

4) Rail stress due to temperature change in bridge superstructure, train acceleration/braking and vertical bending under train

Left track/Freight track

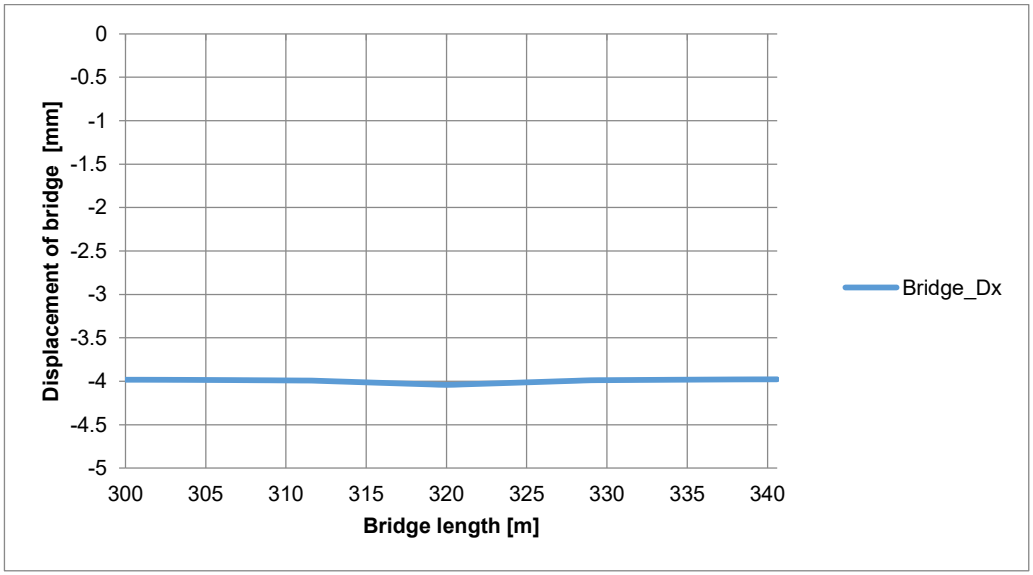
Maximum pressure stress in rail = **-8,06-48,77-0,00 = -56,83 MPa ≤ -72,00 MPa**

Right track

Maximum pressure stress in rail = **-7,23-45,37-0,00 = -52,60 MPa ≤ -72,00 MPa**

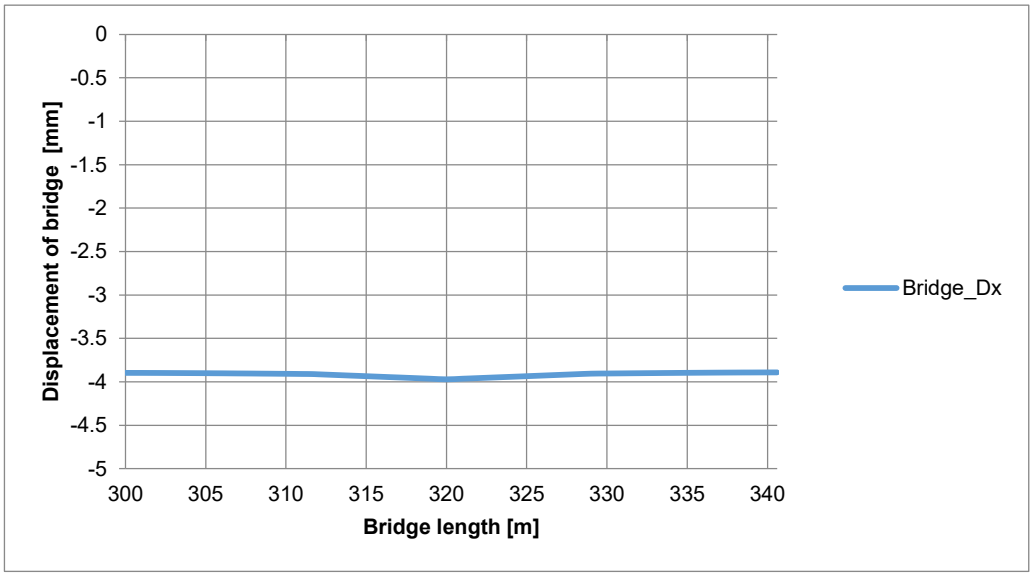
5) Absolute horizontal displacement of bridge superstructure due to acceleration/braking of the train

Left track/Freight track



Maximum absolute horizontal displacement of bridge superstructure due to acceleration/braking of the train = **4,04 mm ≤ 5 mm**

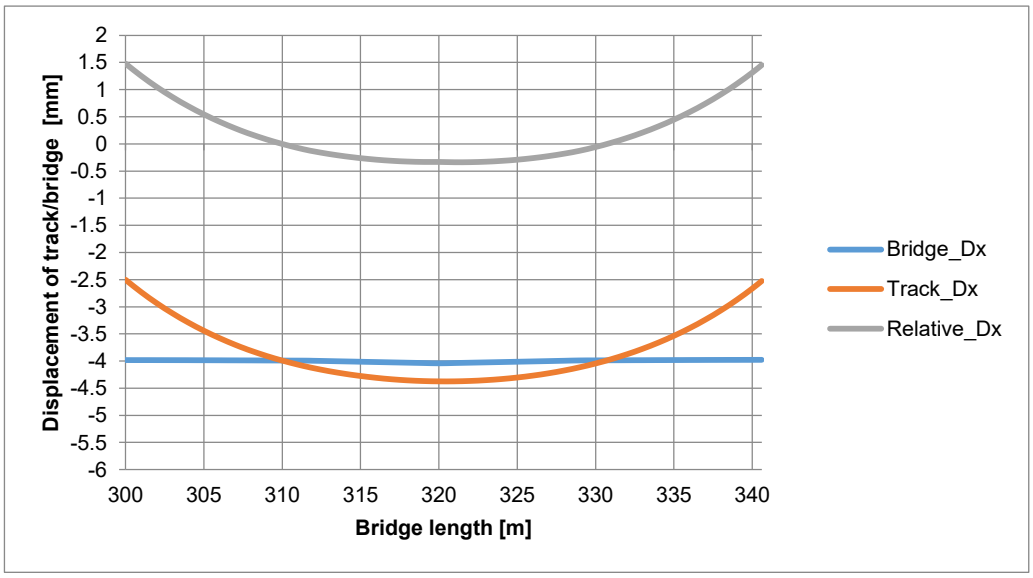
Right track



Maximum absolute horizontal displacement of bridge superstructure due to acceleration/braking of the train = **3,97 mm ≤ 5 mm**

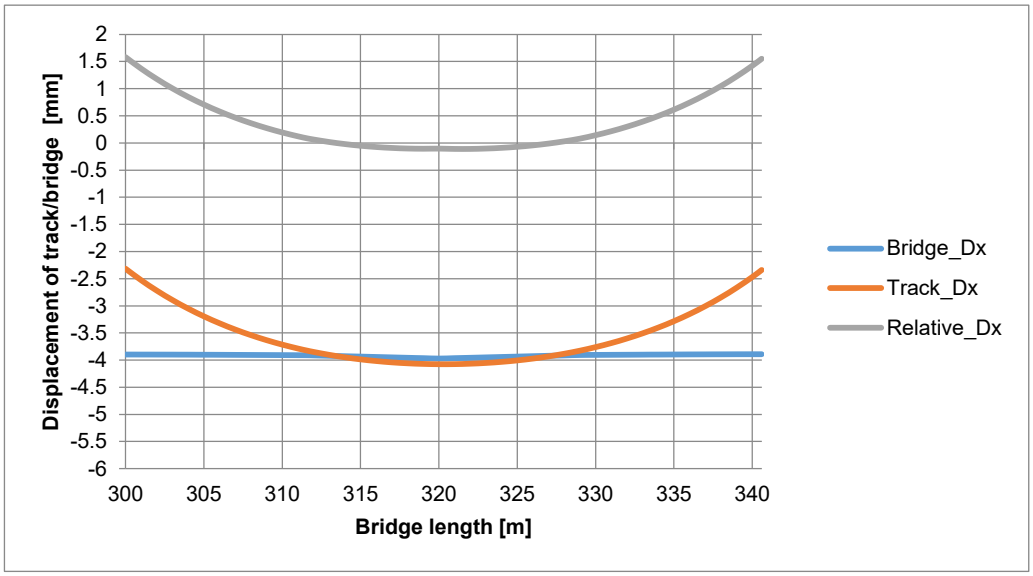
6) Relative horizontal displacement between rail and bridge superstructure due to acceleration/braking of the train

Left track/Freight track (train acceleration)



Maximum relative horizontal displacement between rail and bridge superstructure due to acceleration of the train = **1,48 mm ≤ 4 mm**

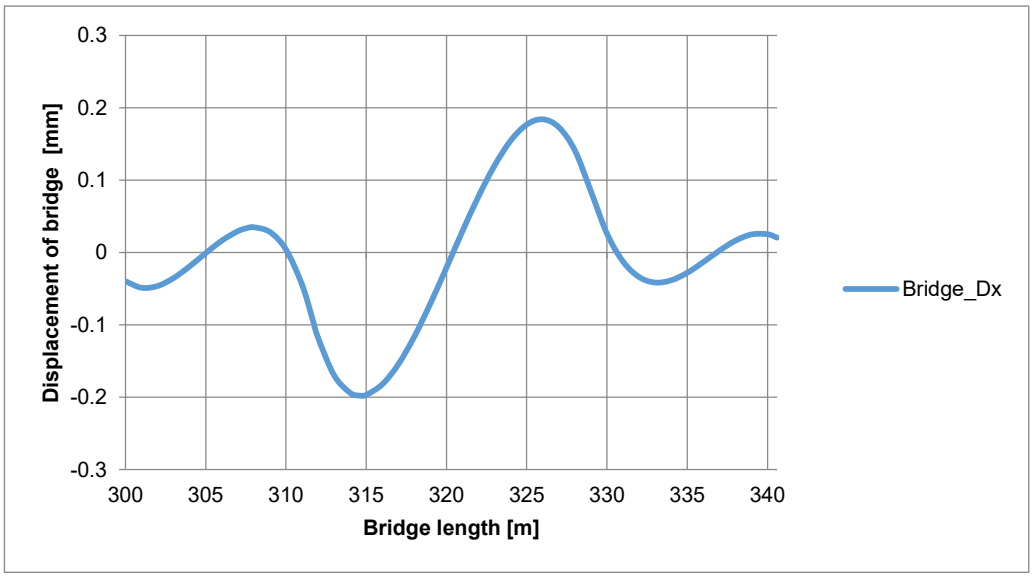
Right track (train braking)



Maximum relative horizontal displacement between rail and bridge superstructure due to braking of the train = **1,58 mm ≤ 4 mm**

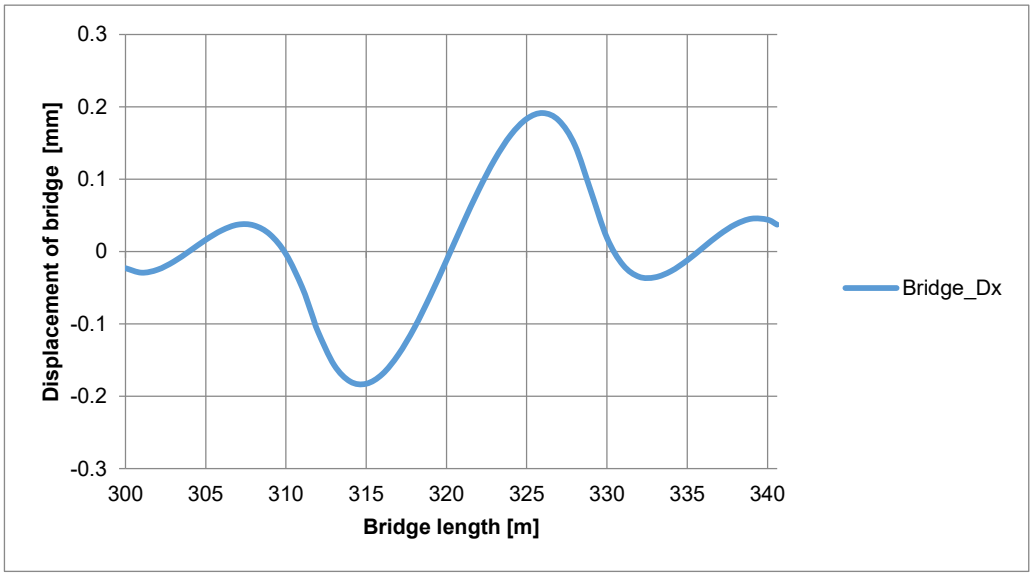
7) Horizontal displacement of bridge superstructure due to rotating of bridge ends under the vertical load of the train

Left track/Freight track



Maximum horizontal displacement of bridge superstructure due to rotating of bridge ends under the vertical load of the train = **0,04 mm < 8 mm**

Right track

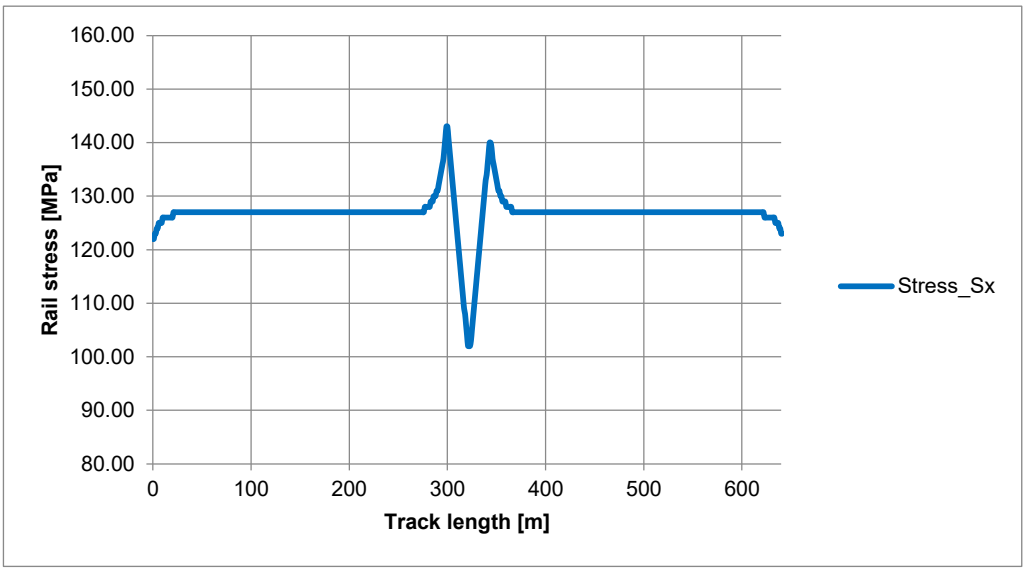


Maximum horizontal displacement of bridge superstructure due to rotating of bridge ends under the vertical load of the train = **0,04 mm < 8 mm**

1.2.1.6 Calculation of track-bridge interaction for winter climatic conditions

1) Rail stress due to temperature change in bridge superstructure and continuously welded rails

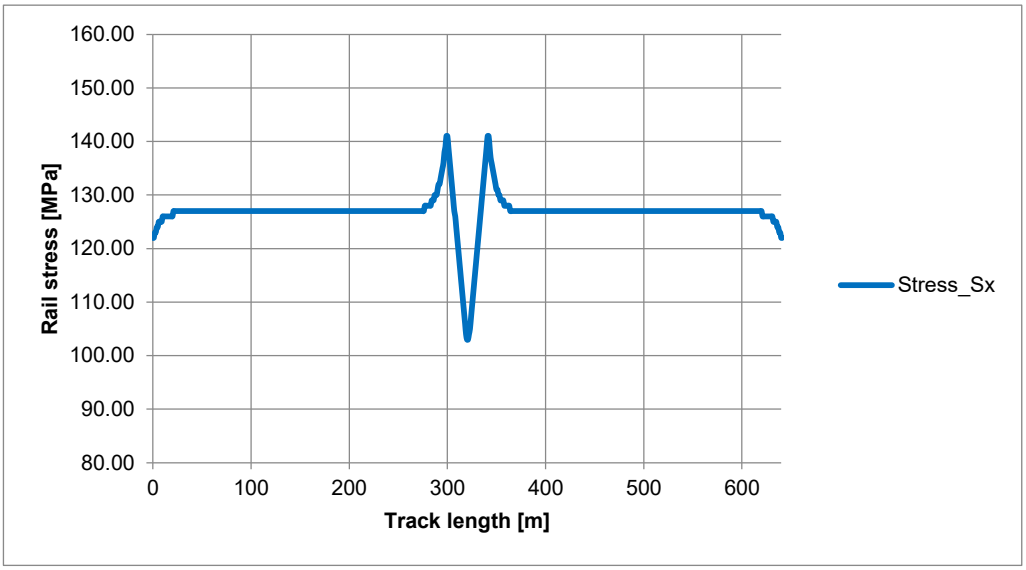
Left track/Freight track



Maximum pressure stress in rail = **0,00 MPa**

Maximum tensile stress in rail = **+15,94 MPa**

Right track

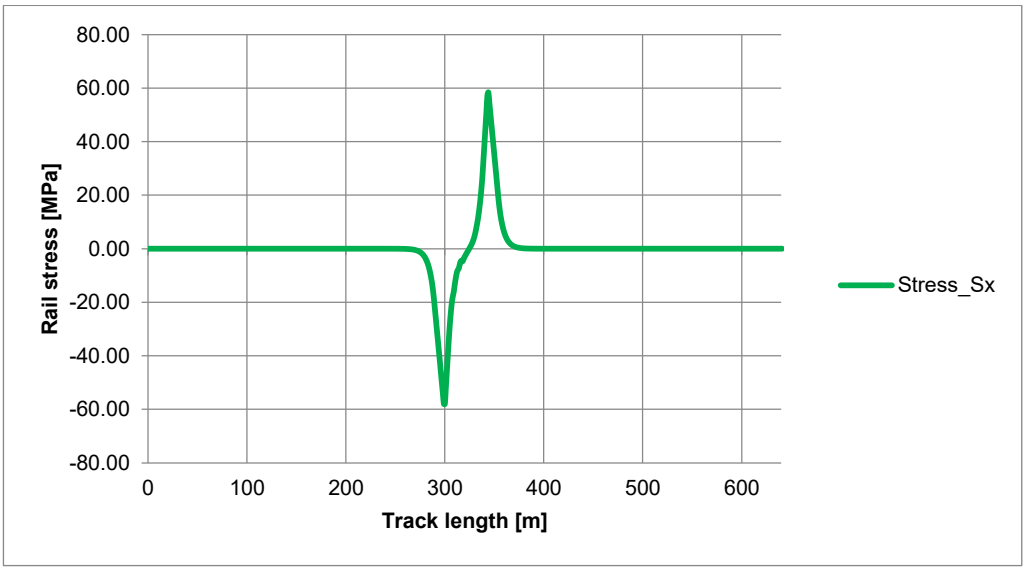


Maximum pressure stress in rail = **0,00 MPa**

Maximum tensile stress in rail = **+14,38 MPa**

2) Rail stress due to train acceleration/braking

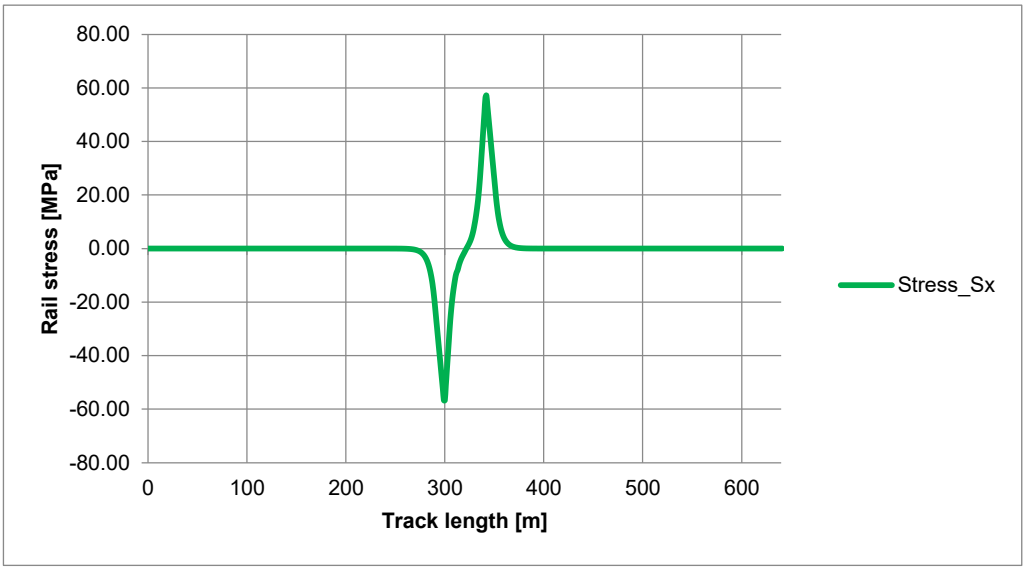
Left track/Freight track (train acceleration)



Maximum pressure stress in rail = **0,00 MPa**

Maximum tensile stress in rail = **+58,45 MPa**

Right track (train braking)

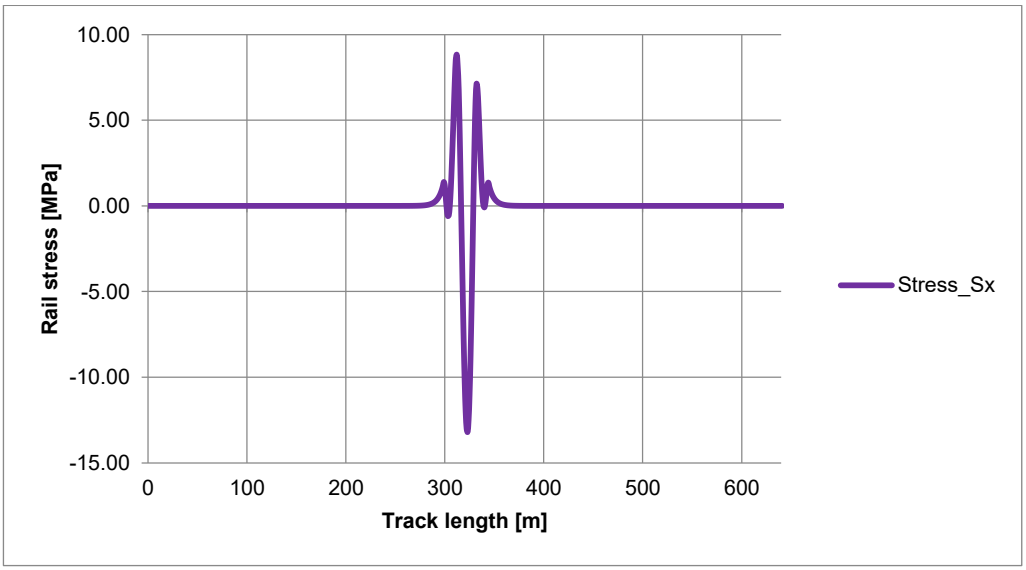


Maximum pressure stress in rail = **0,00 MPa**

Maximum tensile stress in rail = **+57,20 MPa**

3) Rail stress due to vertical bending under train

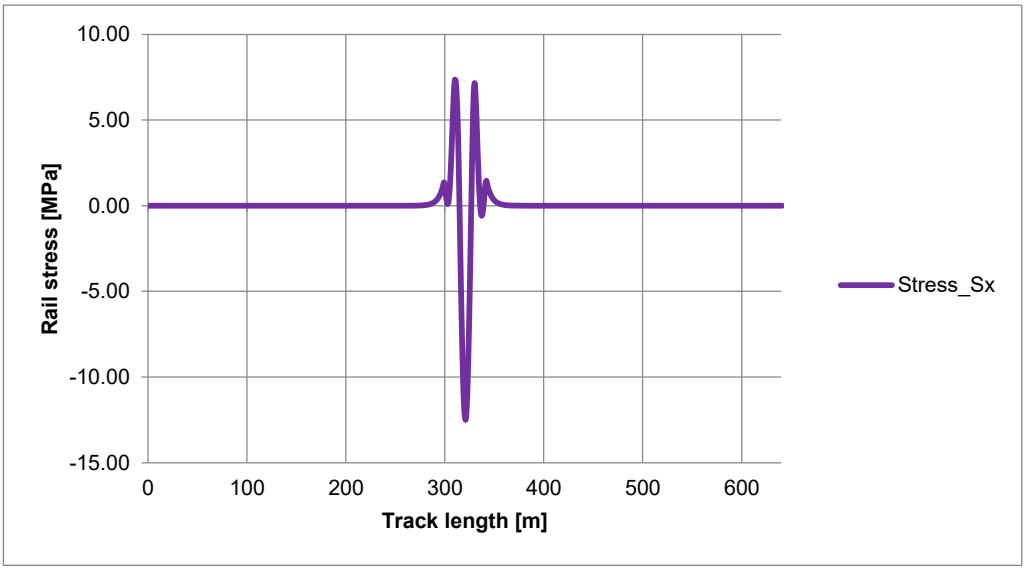
Left track/Freight track



Maximum pressure stress in rail = **0,00 MPa**

Maximum tensile stress in rail = **+1,16 MPa**

Right track



Maximum pressure stress in rail = **0,00 MPa**

Maximum tensile stress in rail = **+1,20 MPa**

4) Rail stress due to temperature change in bridge superstructure, train acceleration/braking and vertical bending under train

Left track/Freight track

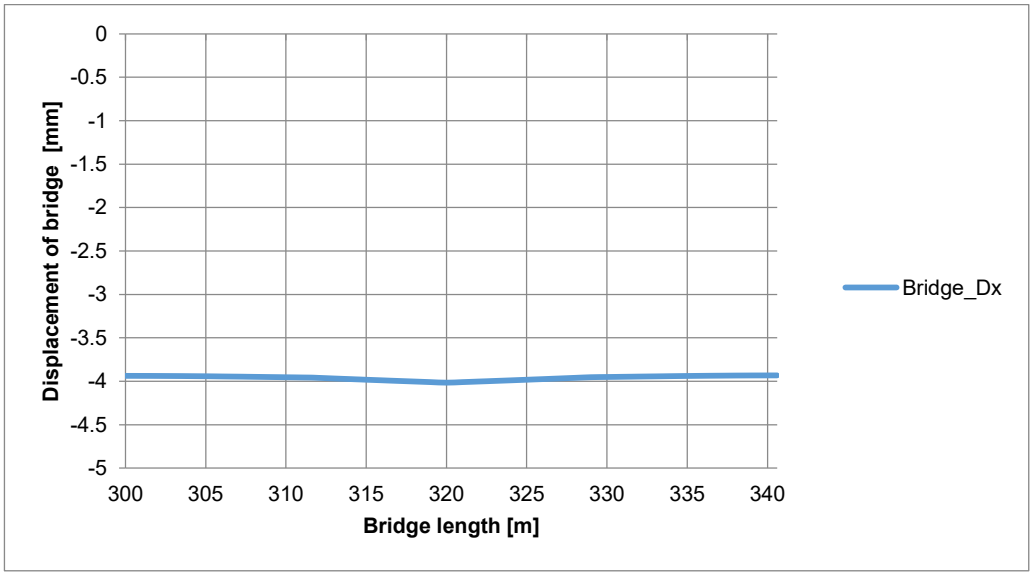
Maximum tensile stress in rail = **+15,94+58,45+1,16 = +75,55 MPa ≤ +92,00 MPa**

Right track

Maximum tensile stress in rail **= +14,38+57,20+1,20 = +72,78 MPa ≤ +92,00 MPa**

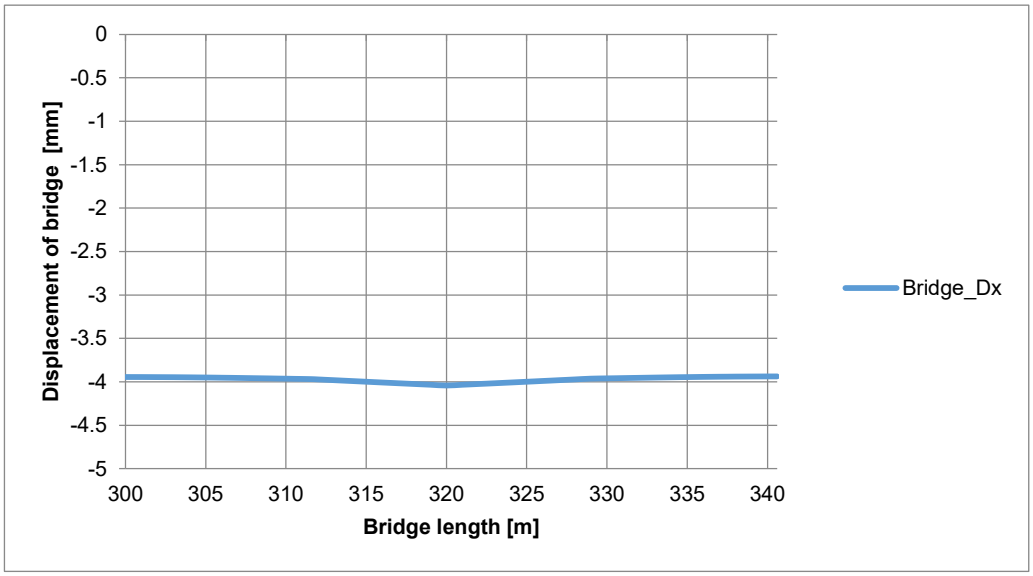
5) Absolute horizontal displacement of bridge superstructure due to acceleration/braking of the train

Left track/Freight track



Maximum absolute horizontal displacement of bridge superstructure due to acceleration/braking of the train = **4,01 mm ≤ 5 mm**

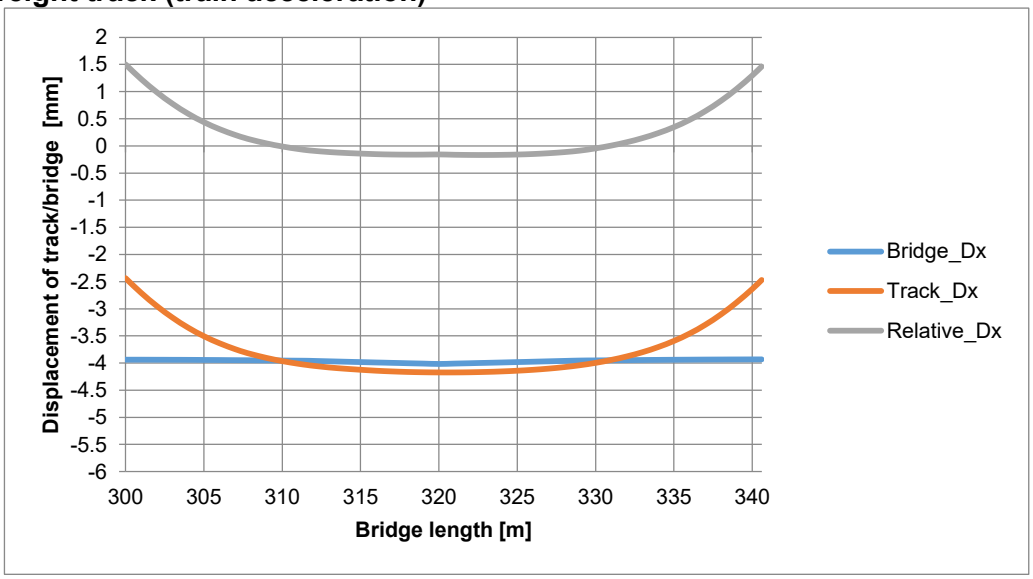
Right track



Maximum absolute horizontal displacement of bridge superstructure due to acceleration/braking of the train = **4,04 mm ≤ 5 mm**

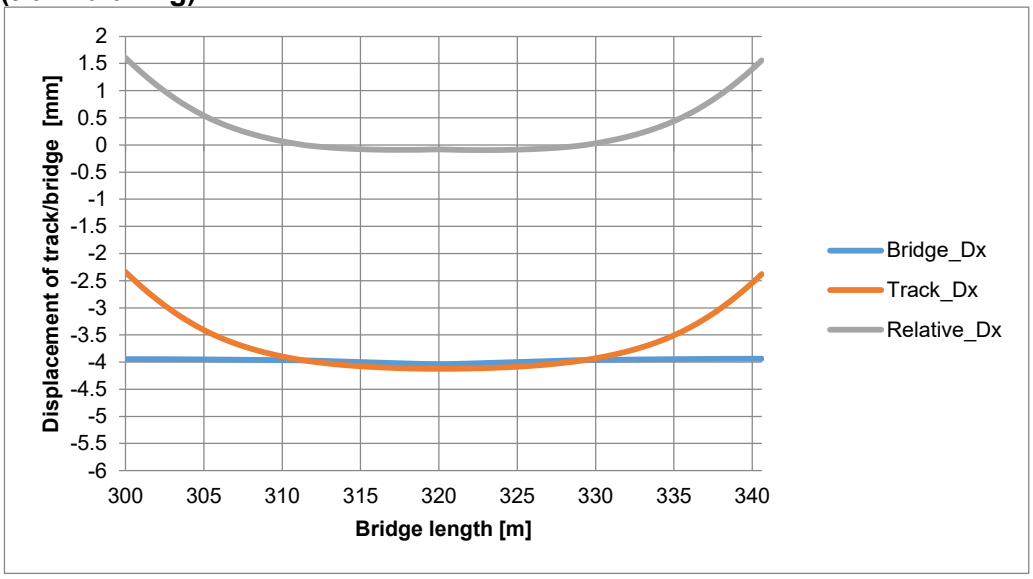
6) Relative horizontal displacement between rail and bridge superstructure due to acceleration/braking of the train

Left track/Freight track (train acceleration)



Maximum relative horizontal displacement between rail and bridge superstructure due to acceleration of the train **= 1,50 mm ≤ 4 mm**

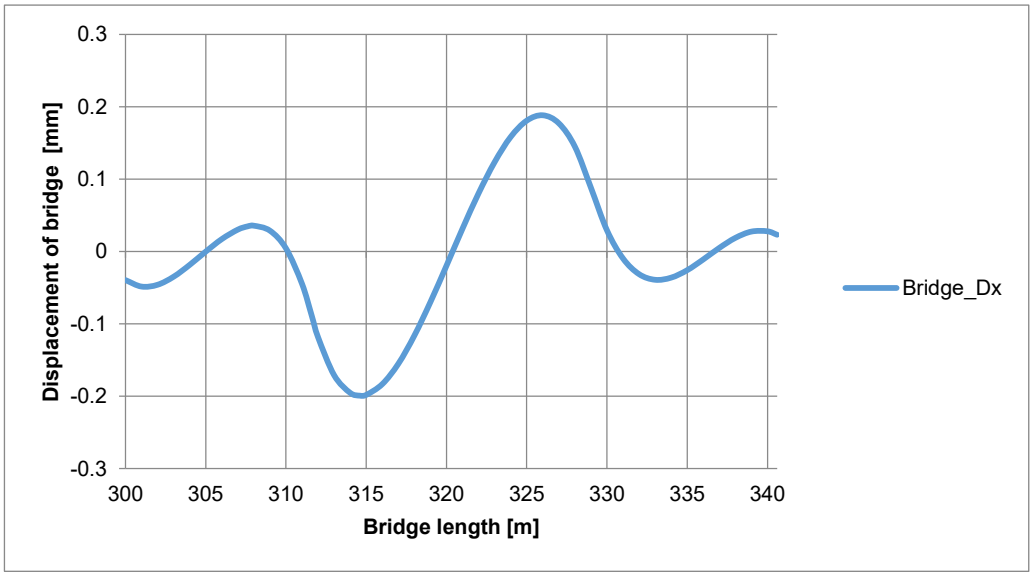
Right track (train braking)



Maximum relative horizontal displacement between rail and bridge superstructure due to braking of the train **= 1,60 mm ≤ 4 mm**

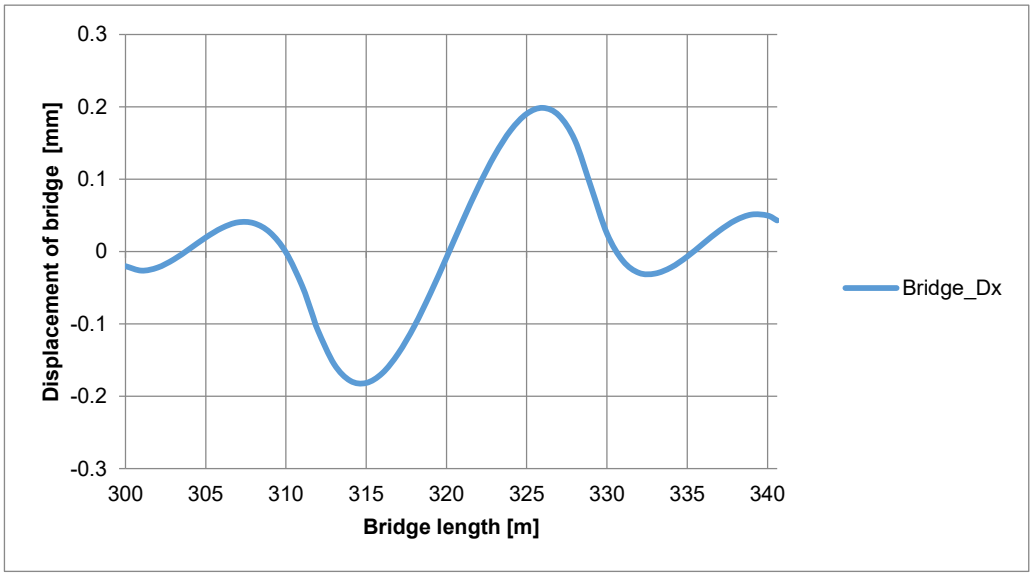
7) Horizontal displacement of bridge superstructure due to rotating of bridge ends under the vertical load of the train

Left track/Freight track



Maximum horizontal displacement of bridge superstructure due to rotating of bridge ends under the vertical load of the train = **0,04 mm < 8 mm**

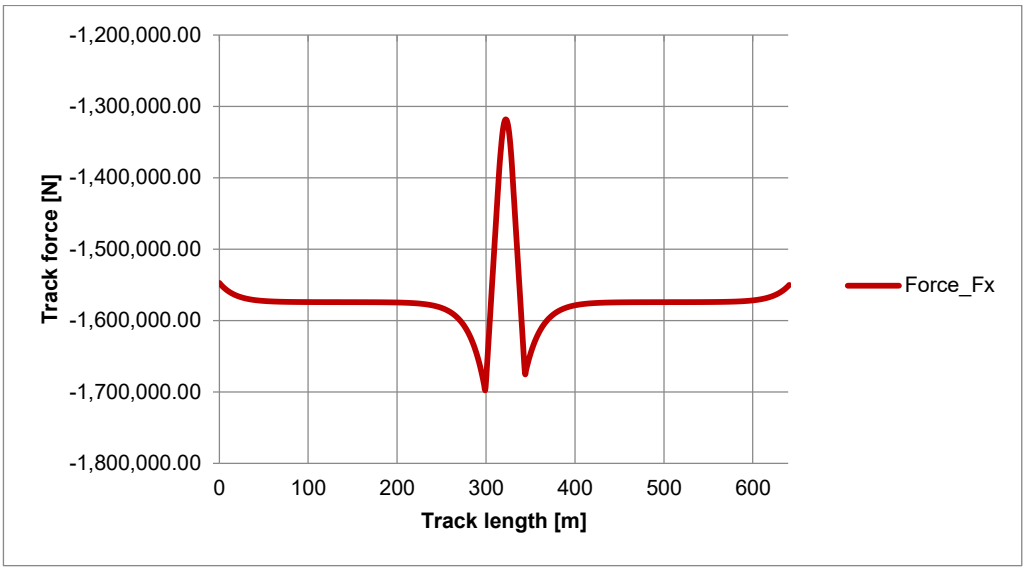
Right track



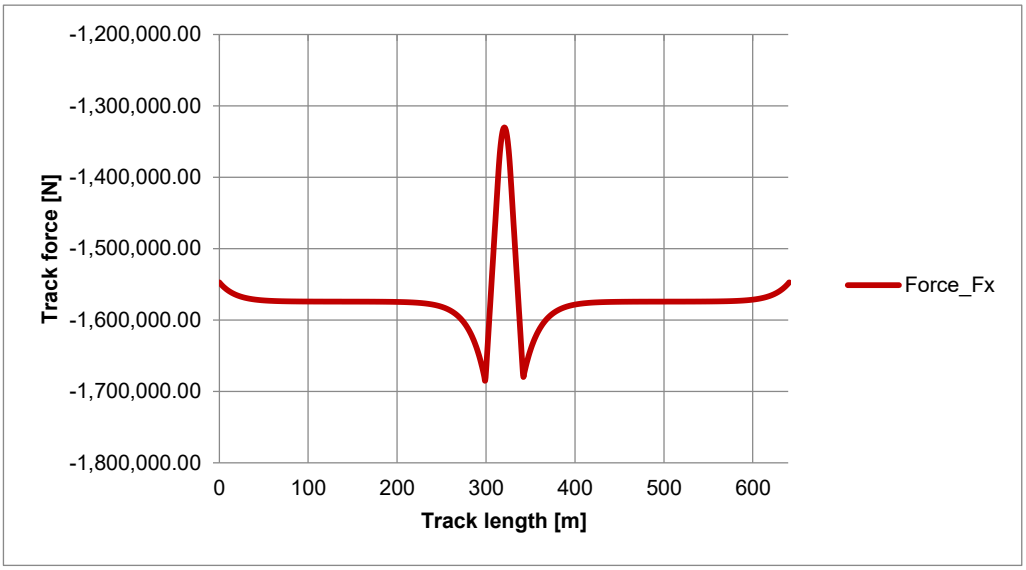
Maximum horizontal displacement of bridge superstructure due to rotating of bridge ends under the vertical load of the train = **0,04 mm < 8 mm**

1.2.1.7 Track stability in the horizontal plane on the bridge in summer climatic conditions

Left track/Freight track



Right track



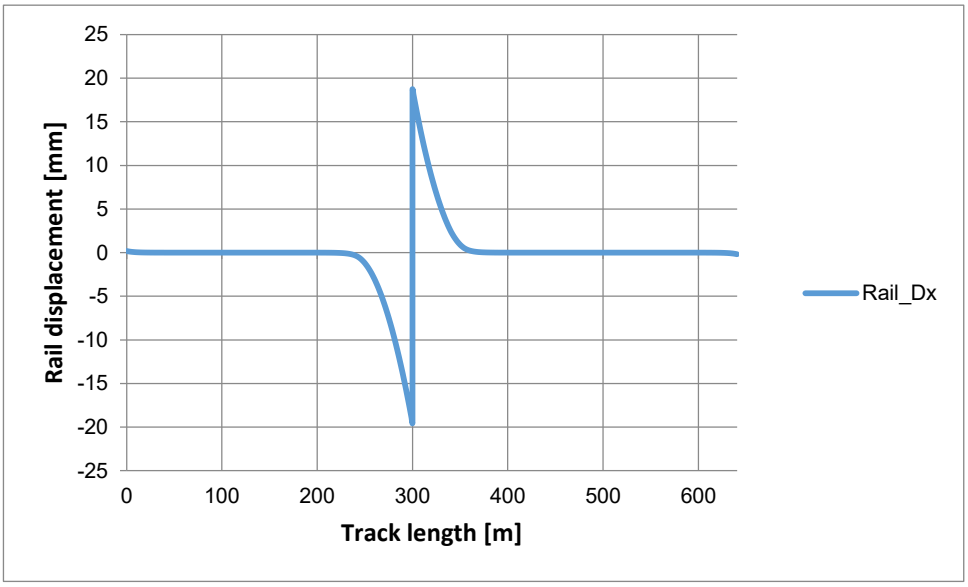
Maximum temperature pressure force in track on the bridge in summer climatic conditions relevant for the calculation of track stability in the horizontal plane = -1697970 N

The input parameters for the calculation of the track stability in the horizontal plane on the bridge in extreme summer climatic conditions are in accordance with Chapters 1.2.1.1, 1.2.1.2 and 1.2.1.3 as well as calculation results of the track/bridge interaction.

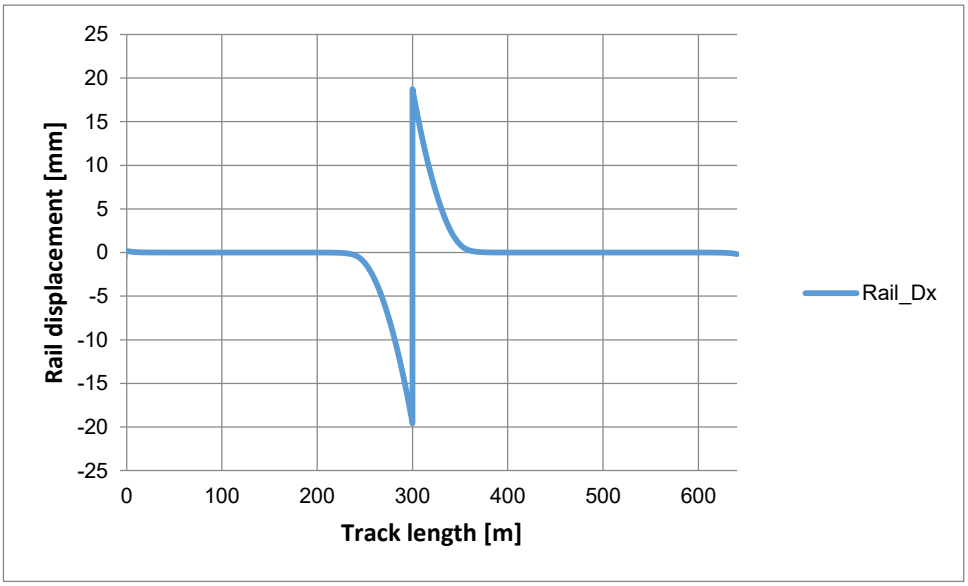
Checking the stability of the track in the horizontal plane was carried out for the maximum value of the pressure force in the track on the bridge -1697970 N.

1.2.1.8 Size of the rail gap on the bridge in winter climatic conditions

Left track/Freight track



Right track



Maximum size of the gap due to cracking of the rail on the bridge in winter climatic conditions in the = **38,26 mm.**

Calculated by:
Zoran Lukovic,dipl.gradj.inz.
licenca broj 310 3032 03

2/2-6.1.6.6.2 CALCULATIONS OF VEHICLE/ TRACK/BRIDGE INTERACTION FOR BRIDGE AT KM 77+814.32 R.T. (77+807.99 L.T.)

CONTENT

1.1 Textual documentation

1.1.1 Technical report

1.1.1.1 Results of the calculation of the track-bridge interaction
1.1.1.2 Results of checking the stability of the track in the horizontal plane on the bridge
1.1.1.3 Results of checking the size of the rail gap on the bridge
1.1.1.4 Technical measures to ensure safety in case of derailment of the vehicle on the bridge

1.2 Numerical documentation

1.2.1 Static calculation

1.2.1.1 Input calculation parameters of the load
1.2.1.2 Input calculation parameters of the track
1.2.1.3 Input calculation parameters of the bridge
1.2.1.4 Calculation model of track-bridge interaction
1.2.1.5 Calculation of track-bridge interaction for summer climatic conditions
1.2.1.6 Calculation of track-bridge interaction for winter climatic conditions
1.2.1.7 Track stability in the horizontal plane on the bridge in summer climatic conditions
1.2.1.8 Size of the rail gap on the bridge in winter climatic conditions

1.1 Textual documentation

1.1.1 Technical report

The calculation of the track-bridge interaction for the purpose of arranging the railway superstructure on the bridge at km 77+807.99 was performed in accordance with the requirements of the Technical Specifications of Interoperability for Infrastructure Subsystem (INF TSI).

Input design load parameters are harmonized with: Technical Specifications of Interoperability for Infrastructure Subsystem, as well as Serbian standards SRPS EN 1991-1-5, SRPS EN 1991-1-5/NA, SRPS EN 1991-2, SRPS EN 1991-2/NA.

In this sense, considered the following load due to:

- relevant temperature changes in the axis of the bridge deck and continuously welded rails,
- vertical load of the vehicle in accordance with the load scheme LM 71, SW/0, SW/2.
- horizontal load due to acceleration and/or braking of the vehicle.

All input calculation data in accordance with the bridge structure, railway superstructure, as well as railway vehicles are shown in Chapters 1.2.1.1, 1.2.1.2 and 1.2.1.3. In accordance with design speed of 80 km/h, a static calculation of the track-bridge interaction was performed. The calculation was performed using an integral model of track and bridge structures, with consideration of:

- bridge parameters: bridge disposition (static system, span, expansion length), geometrical characteristics of the bridge superstructure, stiffness and arrangement of bearings,
- track parameters: rail cross-section and rail steel quality, resistance to longitudinal displacement of unloaded and loaded track, taking into account bilinear behavior,
- load parameters: temperature change in the bridge superstructure, temperature changes in the continuously welded rails, acceleration/braking of vehicles, displacement and rotation of the ends of the bridge superstructure due to traffic load.

The connection between the track and the bridge superstructure was modeled using elastic connections with bilinear behavior. The horizontal stiffness of the supporting elements is defined in the model based on UIC 774-3 recommendations and standard SRPS EN 1991-2. In this way, the influences in the rails are obtained, which are relevant for comparison with the allowed additional stresses, proving the stability of the track in the horizontal plane for maximum summer temperatures, as well as gap size due to rail cracking for maximum winter temperatures. The calculation model takes into account the track with continuously welded rails at the length of the bridge and 300 m before and after the bridge, which corresponds to the maximum influential braking length of the vehicle. The layout of the calculation model is shown in Figures 9-11. A detailed description of the model characteristics is presented in Chapter 1.2.1.4.

1.1.1.1 Results of the calculation of the track-bridge interaction

Horizontal reactions on one (out of a total of nine on the one structure of the bridge) fix bridge bearing on one (out of a total of two) middle pier due to the track-bridge interaction:

Left/Right bridge structure:

Type of load	Summer climatic conditions	Winter climatic conditions
Temperature change in axis of the bridge and continuously welded rails	**±89,96 kN**	**±89,68 kN**
Acceleration + Braking of train	**+43,18 kN**	**+31,39 kN**
Vertical load of train	**±10,96 kN**	**±10,98 kN**
Note 1: The positive direction of the reaction corresponds to the direction of growth of the chainage. Note 2: The combined effect of temperature force, acceleration + braking force and the corresponding vertical load from the train is taken to dimensioning the bridge bearings and piers.		

Maximum additional compressive and tensile stresses in continuously welded rails:

Left/Right bridge structure:

Type of load	**Left track**	**Right track**
Summer climatic conditions		
Temperature change in axis of the bridge and continuously welded rails	-8,17 MPa	-8,17 MPa
Acceleration of train/ Braking of train	-51,10 MPa	-53,40 MPa
Vertical load from the train	0,00 MPa	0,00 MPa
Total additional compressive stresses in the relevant sections of the continuously welded rail	**-59,27 MPa ≤ -62 MPa**	**-61,57 MPa ≤ -62 MPa**
Winter climatic conditions		
Temperature change in axis of the bridge and continuously welded rails	+14,96 MPa	+14,96 MPa
Acceleration of train/ Braking of train	+61,22 MPa	+62,47 MPa
Vertical load from the train	+3,20 MPa	+3,20 MPa
Total additional tensile stresses in the relevant sections of the continuously welded rail	**+79,38 MPa ≤ +92 MPa**	**+80,63 MPa ≤ +92 MPa**
Note 1: Pressure stresses with sign (-), tensile stresses with sign (+)		

Maximum absolute and relative displacements of the track and the bridge superstructure:

Left/Right bridge structure:

Type of displacement	**Summer climatic conditions**	**Winter climatic conditions**
Absolute horizontal displacement of the bridge superstructure due to acceleration/braking of the train	**4,59 mm ≤ 5 mm**	**4,62 mm ≤ 5 mm**
Relative horizontal displacement between the rail and the bridge superstructure due to acceleration/braking of the train	**1,83 mm ≤ 4 mm (braking)** **1,70 mm ≤ 4 mm (acceleration)**	**1,83 mm ≤ 4 mm (braking)** **1,74 mm ≤ 4 mm (acceleration)**
Horizontal displacement due to rotating of the bridge ends under the vertical load from the train	**0,02 mm ≤ 8mm**	**0,02 mm ≤ 8mm**

1.1.1.2 Results of checking the stability of the track in the horizontal plane on the bridge

Input parameters for checking the stability of the track in the horizontal plane on the bridge at extreme summer temperatures in the rails and the bridge superstructure were adopted in accordance with Chapter 1.2.1.7 and based on the results of the calculation of the track-bridge interaction.

Checking the stability of the track in the horizontal plane was carried out for the maximum value of the pressure force in the track on the bridge -1688070 N.

1.1.1.3 Results of checking the size of the rail gap on the bridge

The calculation was performed under the assumption that the maximum longitudinal resistance during elastic displacement of the rail through the system of elastic rail fastening is 30 kN/m, which corresponds to the force of longitudinal resistance 9 kN.

The calculated value of the rail gap in winter conditions is approximately 38,06 mm.

1.1.1.4 Technical measures to ensure safety in case of derailment of the vehicle on the bridge

- The guard rails, to keep trains on the track in the event of derailment, must be installed, as they can provide safety at speeds up to 160 km/h. The role of the guard rails is to keep the vehicle on track if it derailment on the bridge. In that way, the structure of the bridge is protected from damage and other negative consequences of derailment are reduced (for example. the vehicle fell off the bridge after derailment). Guard rails are mounted on sleepers with a flat upper surface. Guard rails are extended by 10 m to the embankments before and after the bridge and are connected in the middle of the track. It is necessary to ensure that the curb upper edge of the concrete bridge deck is 25 cm above the upper edge of the sleeper.

1.2 Numerical documentation

1.2.1 Static calculation

1.2.1.1 Input calculation parameters of the load

Input calculation parameters of load are harmonized with: Technical specifications of interoperability for subsystem of infrastructure, as well as Serbian standards SRPS EN 1991-1-5, SRPS EN 1991-1-5/NA, SRPS EN 1991-2, SRPS EN 1991-2/NA.

Temperature:

- temperature change in continuously welded rails in summer climatic conditions: +42,5 K,
- temperature change in continuously welded rails in winter climatic conditions: -52,5 K,
- temperature change in the bridge superstructure in summer climatic conditions: +35 K,
- temperature change in the bridge superstructure in winter climatic conditions: -35 K.

Vertical load from the train:

- LM71

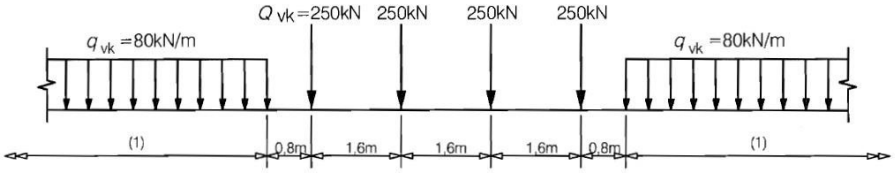
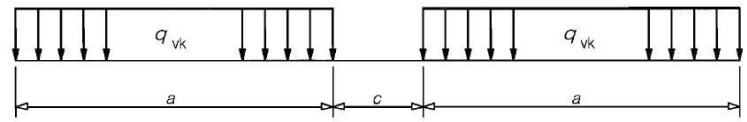


Fig. 2: Load model LM71 (α=1,21)

- SW/0, SW/2



Load Model	q_{vk} [kN/m]	a [m]	c [m]
SW/0	133	15,0	5,3
SW/2	150	25,0	7,0

Fig. 3: Load model SW/0, SW/2 (α=1,21 for SW/0)

Horizontal load from train acceleration/braking LM71, SW/0, SW/2:

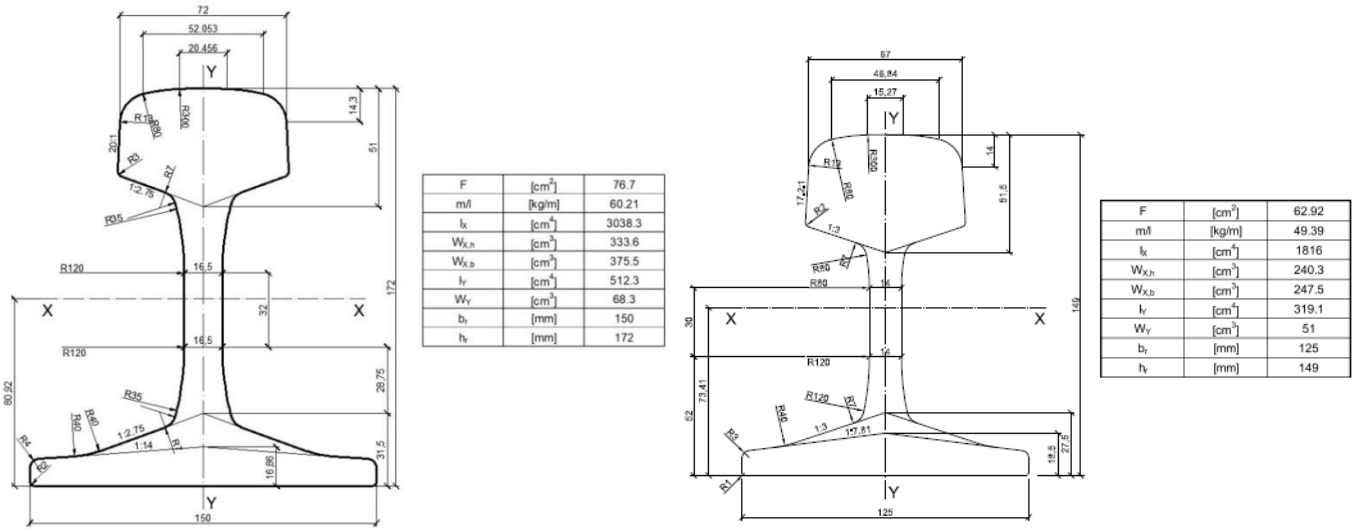
- train acceleration force 33 kN/m (≤1000 kN) for LM71, SW/0, SW/2 (α=1,21 for LM71, SW/0),
- train braking force 20 kN/m (≤6000 kN) for LM71, SW/0 (α=1,21),
- train braking force 35 kN/m for SW/2.

1.2.1.2 Input calculation parameters of the track

The input calculation parameters of the track are harmonized with: Serbian standards SRPS EN 13146-1, SRPS EN 13230 - parts 1 and 2, SRPS EN 13231, SRPS EN 13450, SRPS EN 13481 - parts 1 and 2, SRPS EN 13674-1, SRPS EN 1991-2, Law on the Safety of Railway Transport and Interoperability, as well as the Rulebook on Technical Conditions and Maintenance of the Railway Superstructure.

Rail

- rail cross-section 60E1 (tensile strength of steel 900 N/mm2) in accordance with SRPS EN 13674-1 on main tracks, as well as on side tracks on bridge and 50 m in front and behind of bridge,
- Young's modulus of elasticity of rail steel E=210 GPa,
- permissible additional tensile stress in rail foot 92 MPa for curved track R = 390 m and lateral track displacement resistance of 16.66 kN/m,
- permissible additional pressure stress in rail 62 MPa for curved track R = 390 m and lateral track displacement resistance of 16.66 kN/m,
- Since UIC 774-3 and SRPS EN 1991-2 do not prescribe the reduction of permissible values of additional stresses in the rails when the track is in a curve R <1500 m, the permissible additional stresses in the rails are determined taking into account the size of the radius of curvature and the value of the resistance to lateral displacement of the track in the curve,
- thermal expansion coefficient of rail steel $\alpha=1,15x10^{-5}$ 1/K.



F	[cm²]	76.7
m/l	[kg/m]	60.21
I_x	[cm⁴]	3038.3
$W_{x,h}$	[cm³]	333.6
$W_{x,b}$	[cm³]	375.5
I_y	[cm⁴]	512.3
W_y	[cm³]	68.3
b_r	[mm]	150
h_r	[mm]	172

F	[cm²]	62.92
m/l	[kg/m]	49.39
I_x	[cm⁴]	1816
$W_{X,h}$	[cm³]	240.3
$W_{X,b}$	[cm³]	247.5
I_y	[cm⁴]	319.1
W_Y	[cm³]	51
b_r	[mm]	125
h_r	[mm]	149

Fig. 4: Rail cross-section 60E1 and 49E1 with geometric characteristics

Note: Due to exceeding the permissible values of additional stresses in the rails 49E1, the replacement type of rail 49E1 to the type of rail 60E1 on the side tracks on the bridge as well as in the zones 50 m in front of and behind the bridge is conducted.

Elastic rail fastening systems

For concrete sleepers in accordance with a series of Serbian standards SRPS EN 13481 - parts 1 and 2 and SRPS EN 13146-1.

- minimum longitudinal resistance to rail displacement ≥ 7 kN (calculated with 9 kN) in accordance with SRPS EN 13674-1.

Mono block prestressed concrete sleepers with a flat top surface

In accordance with a series of Serbian standards SRPS EN 13481-2 and SRPS EN 13230 - parts 1 and 2.

- minimum sleeper mass 281 kg without rail fastening,
- sleeper length 260 cm,
- longitudinal axial distance between sleepers 60 cm,
- minimum active backing surface of sleeper on ballast 0,57 m^2.

Lateral track stability

- required minimum value of lateral track resistance of 16.66 kN/m on the bridge and in zones of 50 m in front of and behind the bridge.

Ballast prism of gravel

In accordance with a series of Serbian standards SRPS EN 13450 with the dimensions of the ballast prism according to SRPS EN 13231.

- the minimum thickness of the ballast prism on the bridge below the lower edge of the sleeper in the cross-section below the rail 35 cm,
- width of the shoulder part of the ballast prism on the concrete deck of the bridge > 50 cm,
- resistance of the ballast prism to the longitudinal displacement of the unloaded track k=20 kN/m in accordance with SRPS EN 1991-2,
- resistance of the ballast prism to the longitudinal displacement of the loaded track k=60 kN/m in accordance with SRPS EN 1991-2.

1.2.1.3 Input calculation parameters of the bridge

The input design parameters of the bridge are defined in accordance with the characteristics of the bridge structure.

- the bridge is a continuous girder static system with spans 11.60 m + 18.85 m + 11.60 m,
- the bridge superstructure consists of two mutually dilated composite bridge structures,
- steel I profiles are constructed from steel grade S355,
- concrete deck is made of concrete class C35/45,
- the support of bridge superstructure is done over 52 bearings, 8 on each abutment, and 18 on each middle pier,

- the required minimum longitudinal (horizontal) stiffness of the supports of bridge superstructure due to acceleration/braking train is ≥ 250000 kN/m,
- the expansion length of the bridge is L_T=21.03 m,
- bridge is straight,
- on the bridge there are a four track of railway in curve approximately R=390 m designed for speed V_p=80 km/h,
- the maximum permissible longitudinal relative displacement between the continuously welded rail and the bridge superstructure due to acceleration/braking of the train is ≤ 4 mm,
- the maximum permissible longitudinal absolute displacement of the bridge superstructure due to acceleration/braking of the train is ≤ 5 mm,
- the maximum permissible longitudinal displacement of the bridge superstructure due to the rotation of the ends of the bridge superstructure under the vertical load from the train is ≤ 8 mm.

Longitudinal section

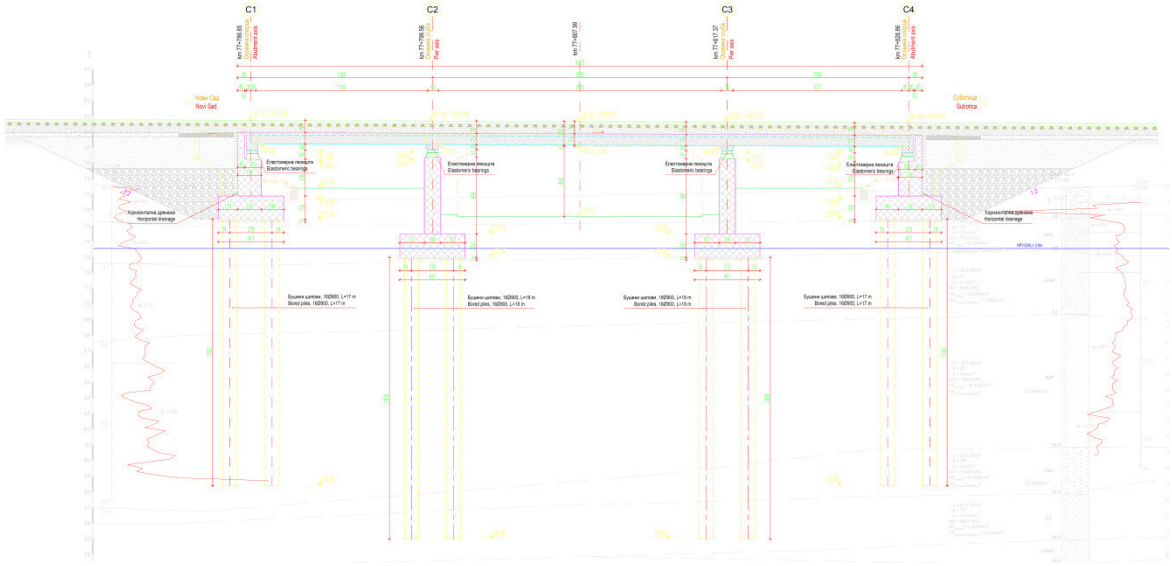


Fig. 5: Longitudinal section of the bridge on km 77+807.99

Cross-section

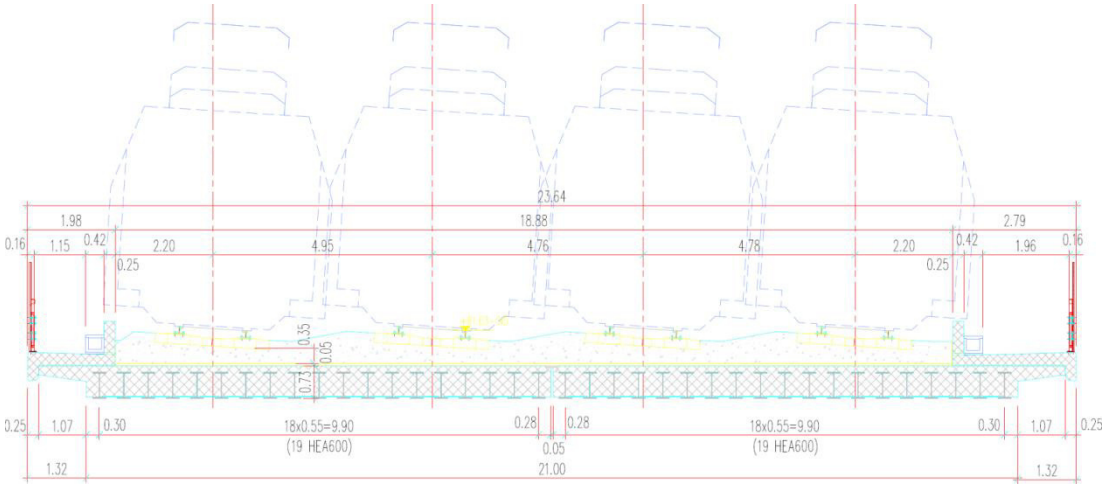


Fig. 6: Cross-section of the bridge on km 77+807.99

Bearing scheme

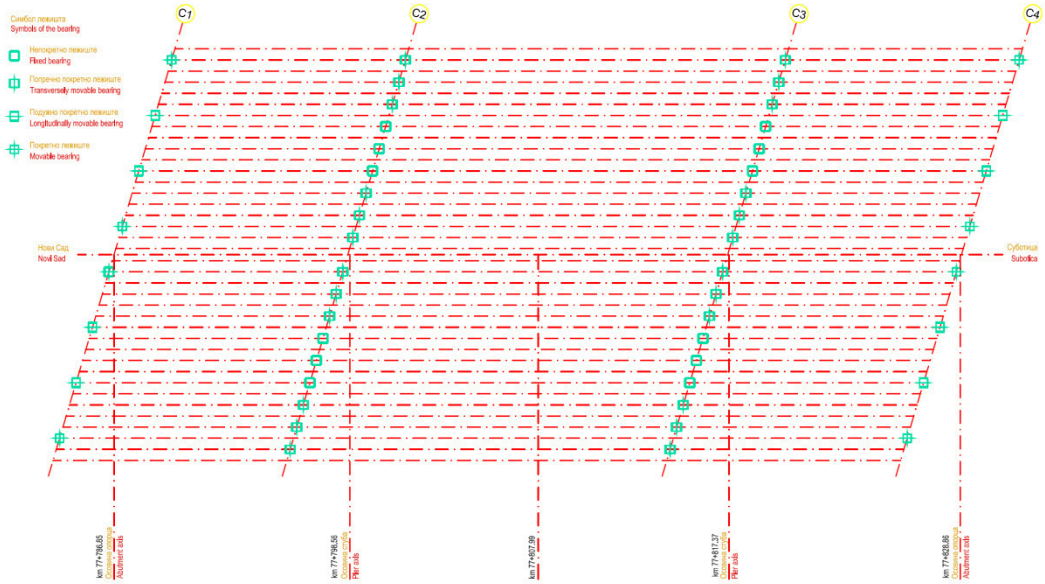
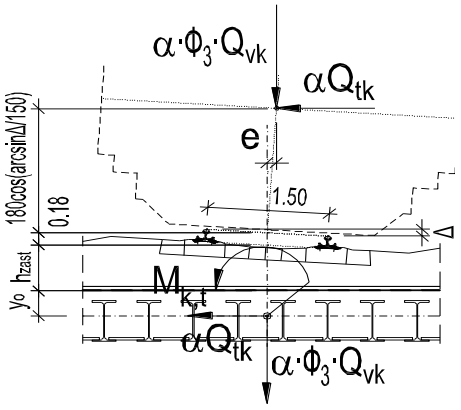


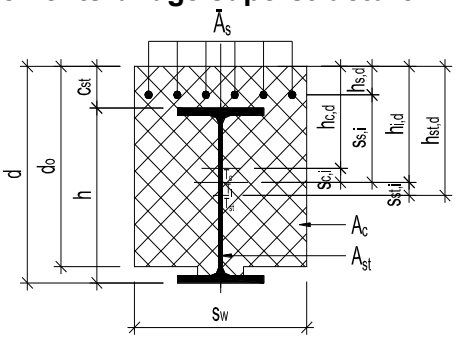
Fig. 7: Bearing scheme of bridge on km 77+807.99



R= 390 m v= 80 km/h Δ= 11.5 cm h_{zast}= 60 cm

	$Q_{v,1}$ [kN]	Φ_3	$\alpha\cdot\Phi_3\cdot Q_{v,1}$ [kN]	e [m]	$M_{v,t}$ [kNm]	$\alpha\cdot Q_{tk}$ [kN]	y_0 [m]	e_{tk} [m]	$M_{tk,t}$ [kNm]
LM71	250	1.261	381.5	0.138	-52.6	39.09	0.36	2.93	114.7
/m'	80	1.261	122.1	0.138	-16.8	12.51	0.36	2.93	36.7
SW/0 /m'	133	1.261	203.0	0.138	-28.0	20.79	0.36	2.93	61.0
	Q_{vk} [kN]	Φ_3	$Q_{v,1}$ [kN]	e [m]	$M_{v,t}$ [kNm]	Q_{tk} [kN]	y_0 [m]	e_{tk} [m]	$M_{tk,t}$ [kNm]
SW/2 /m'	150	-	150.0	0.138	-20.7	19.38	0.36	2.93	56.9

Geometrical characteristics of elements bridge superstructure



set	d [cm]	A_{st} [cm^2]	$I_{t,st}$ [cm^4]	I_{st} [cm^4]	h [cm]	$h_{st,d}$ [cm]	d_o [cm]	s_w [cm]	A_c [cm^2]	I_c [cm^4]	c_{st} [cm]	$h_{c,d}$ [cm]	$\bar{A}_s$ [cm^2]	$h_{s,d}$ [cm]
1	73	226	352	141208	59	43,5	67,5	55	3581	1379674	14	34,1	0	0
2	73	226	352	141208	59	43,5	67,5	55	3581	1379674	14	34,1	29,46	7,95

	Kratkotrajna opterećenja n_i= 6					
set	A_i [cm^2]	$h_{i,d}^0$ [cm]	$s_{st,i}$ [cm]	$s_{c,i}$ [cm]	$s_{s,i}$ [cm]	I_i [cm^4]
1	823	36,38	-7,12	2,25	0,00	385643
2	852	35,51	-7,99	1,39	27,56	387506

	Dugotrajna opterećenja n_v= 18					
set	A_i [cm^2]	$h_{i,d}^0$ [cm]	$s_{st,i}$ [cm]	$s_{c,i}$ [cm]	$s_{s,i}$ [cm]	I_i [cm^4]
1	425	38,98	-4,52	4,85	0,00	227160
2	454	37,02	-6,48	2,89	29,07	229891

Material characteristics of the elements bridge superstructure

Steel I profile are of steel grade S355 with the following characteristics:

Steel grade S355:

- $E=2,1x10^8$ kN/m^2
- v=0,3
- $\alpha=1,2x10^{-5}$ 1/C
- $\rho=76,98$ kN/m^3

Concrete deck is made of concrete class C35/45 with the following characteristics:

Concrete class C35/45:

- $E= 3,4077x10^7$ kN/m^2
- v=0,2
- $\alpha=1,0x10^{-5}$ 1/C
- $\rho=23,54$ kN/m^3

Steel reinforcement in the concrete is grade B500B:

Steel reinforcement grade B500B:

- $E=2,1x10^8$ kN/m^2
- v=0,3
- $\alpha=1,2x10^{-5}$ 1/C
- $\rho=76,98$ kN/m^3

1.2.1.4 Calculation model of track-bridge interaction

Based on the calculation of the track-bridge interaction, the influences are obtained in the following form:

- longitudinal forces in supports (reactions of fixed supports),
- additional stresses in rails,
- absolute and relative displacements of the rails and the bridge superstructure.

Influences due to interaction are determined iteratively, by a series of nonlinear simulations, in order to determine the behavior of the track-bridge system, due to temperature changes in the bridge superstructure, vertical load from the train and longitudinal forces due to train acceleration/braking.

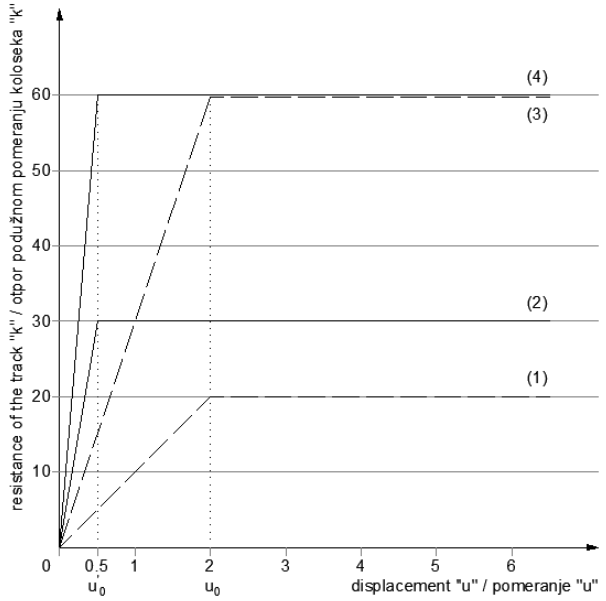
The calculation of the track-bridge interaction is carried out using an integral model of track and bridge structure taking into account:

- bridge parameters: bridge disposition (static system, spans, expansion lengths), geometrical characteristics of the bridge superstructure, stiffness of structure and arrangement of supports,
- track parameters: rail cross-section and rail steel quality, resistance to longitudinal displacement of loaded and unloaded track, taking into account the bilinear behavior of the track-bridge connection,

- load parameters: temperature changes in the bridge superstructure and rails, acceleration and braking of the train, displacement and rotating the ends of the bridge super structure due to traffic load.

The connection between the track elements and the bridge superstructure elements was modeled by means of elastic connections with bilinear behavior in accordance with the Serbian standard SRPS EN 1991-2 (Figure 8).

In the model adopted horizontal stiffness of the fixed support, which corresponds to the real displacement of the bridge superstructure due to acceleration/braking the train. In this way, the influences in the rails are obtained, which are relevant for the analysis of the allowed additional stresses and track stability in the horizontal plane at maximum summer temperature, as well as the size of the gap when the rail cracks at maximum winter temperature. The calculation model takes into account the track with continuously welded rails at a length of 300 m in before and after the bridge, which corresponds to the maximum influential length of train braking.



(1) - resistance of sleeper in ballast (unloaded track)
otpor podužnom pomeranju praga kroz zastor (neopterećen kolosek)

(2) - resistance of rail in sleeper (unloaded track) (frozen ballast or track without ballast)
otpor podužnom pomeranju šine u odnosu na prag (neopterećen kolosek) (smrznuti zastor ili kolosek na čvrstoj podlozi)

(3) - resistance of sleeper in ballast (loaded track)
otpor podužnom pomeranju praga kroz zastor (opterećen kolosek)

(4) - resistance of rail in sleeper (loaded track) (frozen ballast or track without ballast)
otpor podužnom pomeranju šine u odnosu na prag (opterećen kolosek) (smrznuti zastor ili kolosek na čvrstoj podlozi)

u'_0 - ultimate relative displacement of the rail to the sleeper
granično relativno pomeranje šine u odnosu na prag

u_0 - ultimative relative displacement of the sleeper in the ballast
granično relativno pomeranje praga u odnosu na zastor

Note: / Napomena:
rail profile 60E1, concrete sleepers B70 at a distance of 60 cm and longitudinal resistance of the rail in the track 2x9 kN, minimum thickness of the compacted ballast below the sleeper is 30 cm.
šine 60E1, betonski pragovi B70 na razmaku 60 cm i podužni otpor šina u koloseku 2x9 kN, minimalna debljina zbijenog zastora ispod praga 30 cm.

Fig. 8: Longitudinal displacement resistance of track/rail

View of calculation model

Left/Right bridge structure

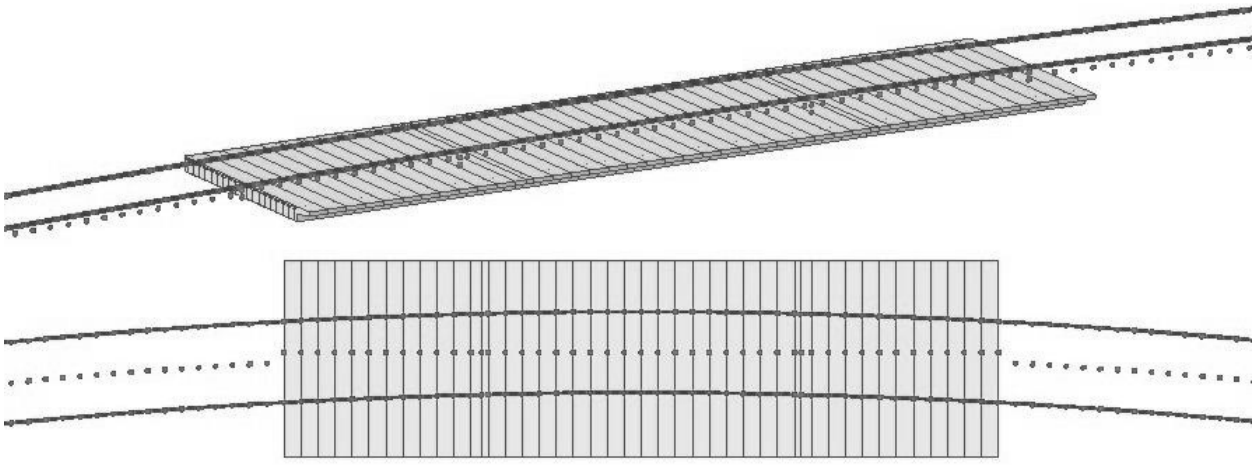


Fig. 9: View of calculation model in curve

Longitudinal section of the calculation model

Left/Right bridge structure

Fig. 10: Longitudinal section of the calculation model

Cross-section of calculation model

Left/Right bridge structure

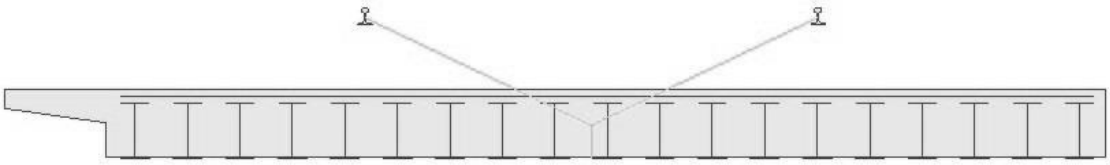
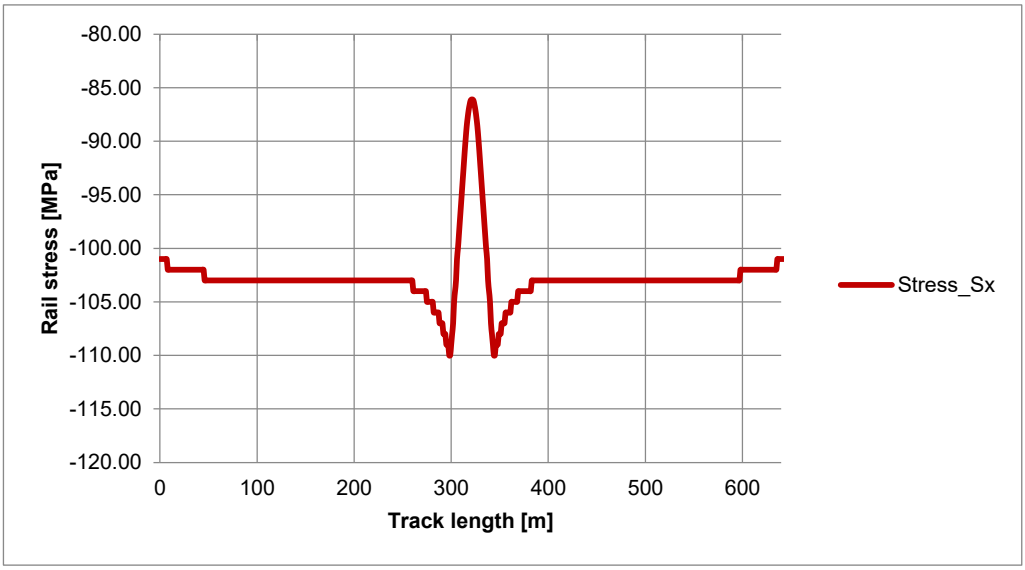


Fig. 11: Cross-section of the calculation model with elastic connections with bilinear behavior between the track and the bridge superstructure

1.2.1.5 Calculation of track-bridge interaction for summer climatic conditions

1) Rail stress due to temperature change in bridge superstructure and continuously welded rails

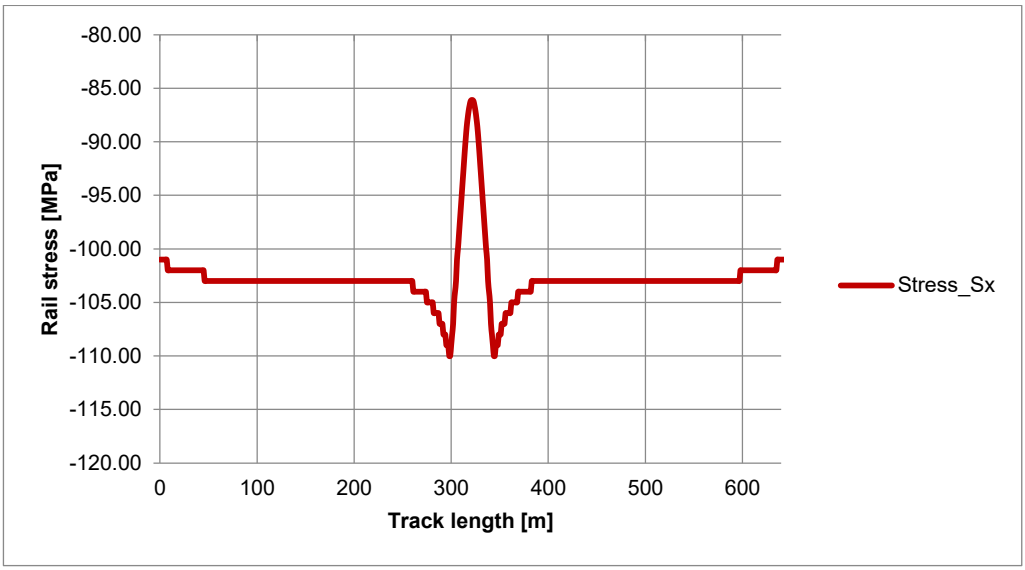
Left track



Maximum pressure stress in rail = **-8,17 MPa**

Maximum tensile stress in rail = **0,00 MPa**

Right track

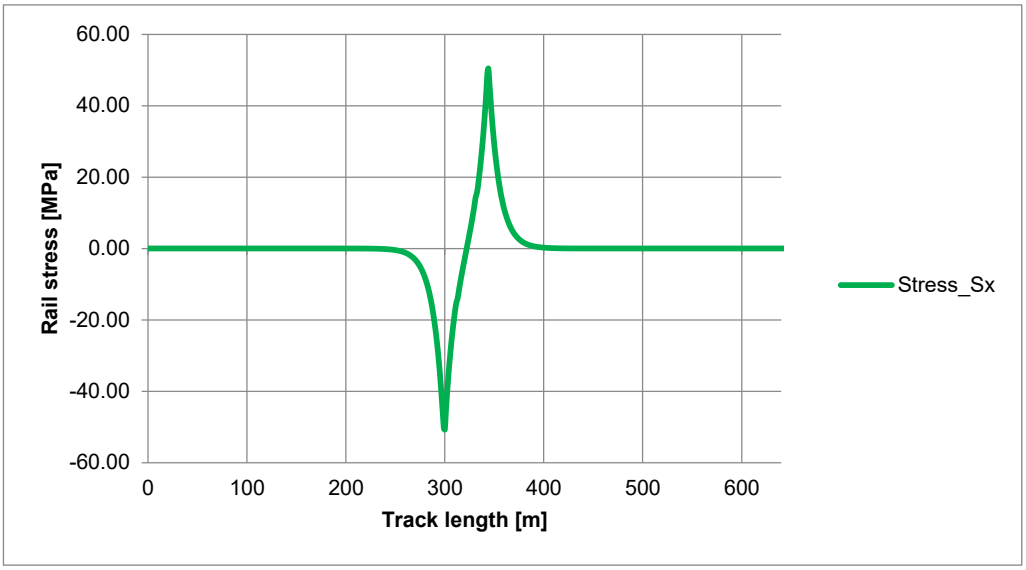


Maximum pressure stress in rail = **-8,17 MPa**

Maximum tensile stress in rail = **0,00 MPa**

2) Rail stress due to train acceleration/braking

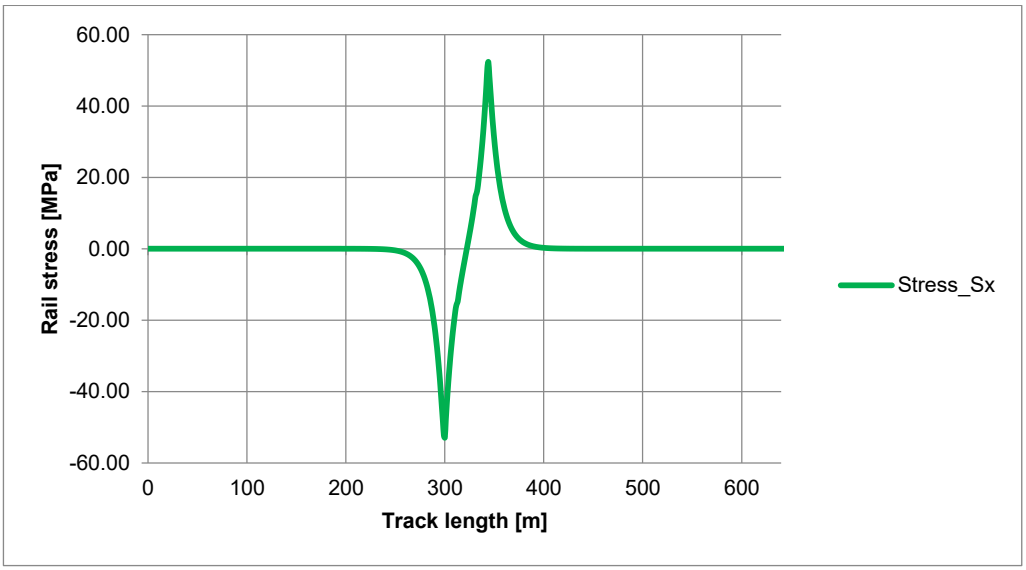
Left track (train braking)



Maximum pressure stress in rail = **-51,10 MPa**

Maximum tensile stress in rail = **0,00 MPa**

Right track (train acceleration)

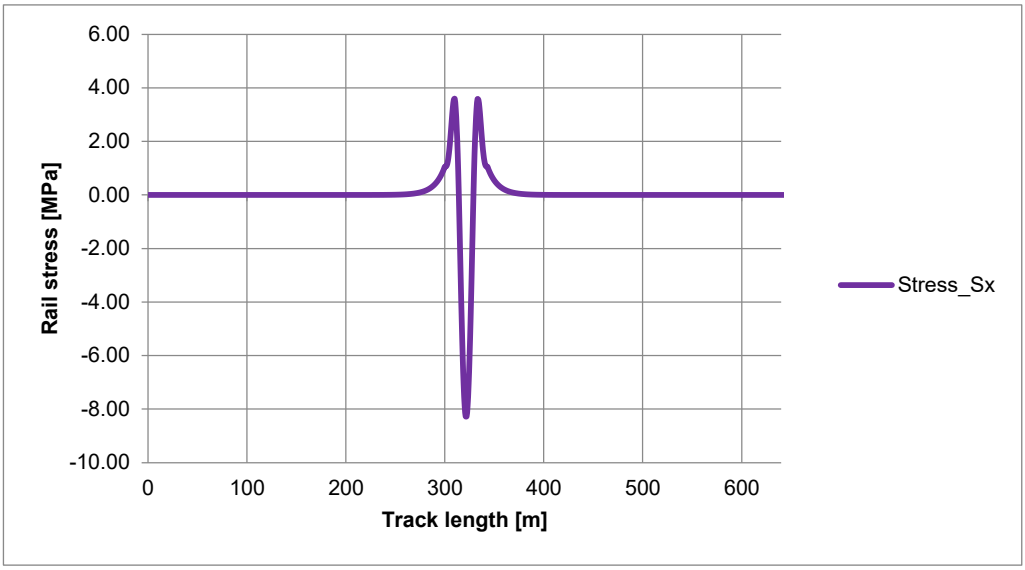


Maximum pressure stress in rail = **-53,40 MPa**

Maximum tensile stress in rail = **0,00 MPa**

3) Rail stress due to vertical bending under train

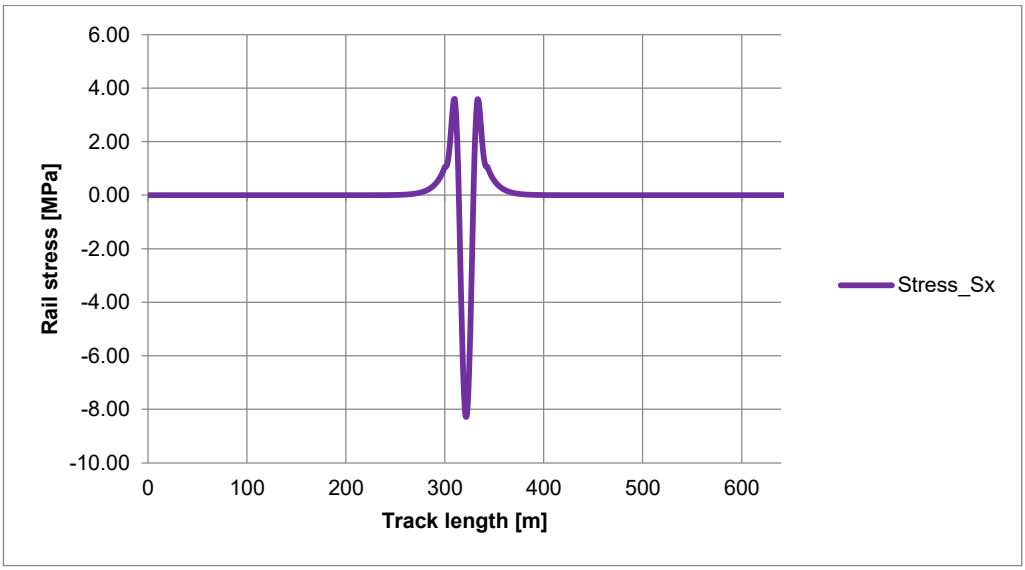
Left track



Maximum pressure stress in rail = **0,00 MPa**

Maximum tensile stress in rail = **+1,43 MPa**

Right track



Maximum pressure stress in rail = **0,00 MPa**

Maximum tensile stress in rail = **+1,43 MPa**

4) Rail stress due to temperature change in bridge superstructure, train acceleration/braking and vertical bending under train

Left track

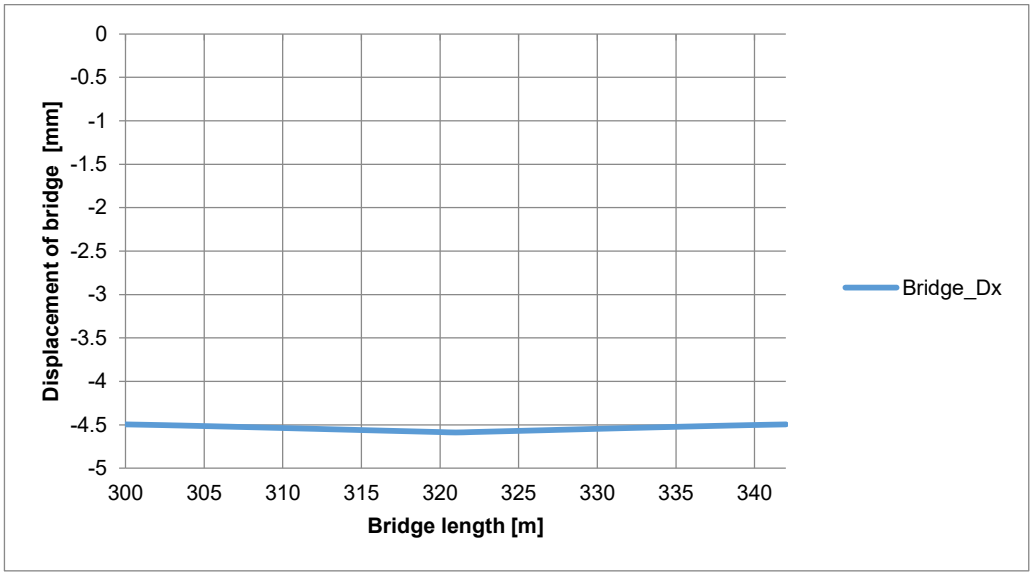
Maximum pressure stress in rail = **-8,17-51,10-0,00 = -59,27 MPa ≤ -62,00 MPa**

Right track

Maximum pressure stress in rail = **-8,17-53,40-0,00 = -61,57 MPa ≤ -62,00 MPa**

5) Absolute horizontal displacement of bridge superstructure due to acceleration/braking of the train

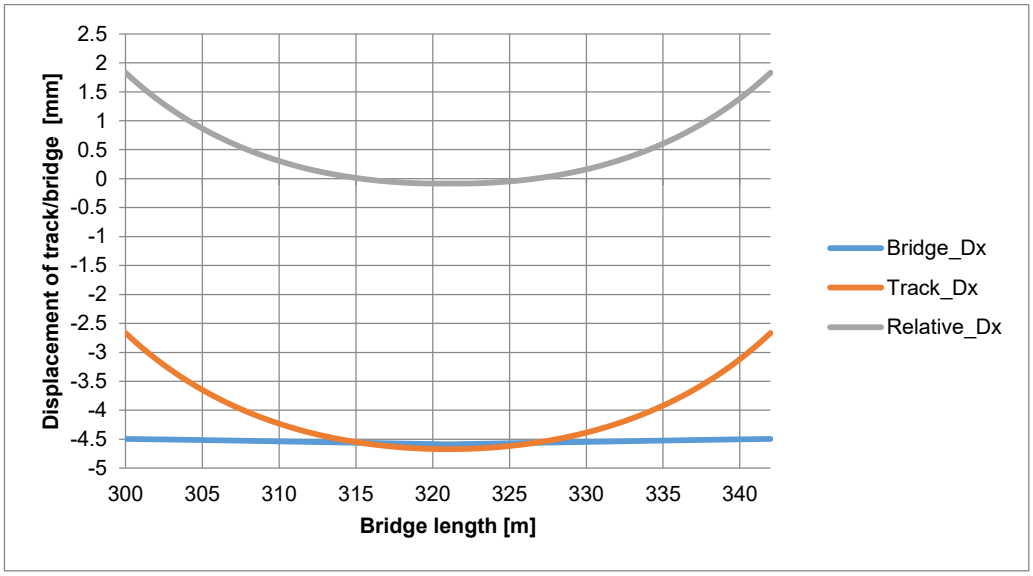
Left/Right bridge structure



Maximum absolute horizontal displacement of bridge superstructure due to acceleration/braking of the train = **4,59 mm ≤ 5 mm**

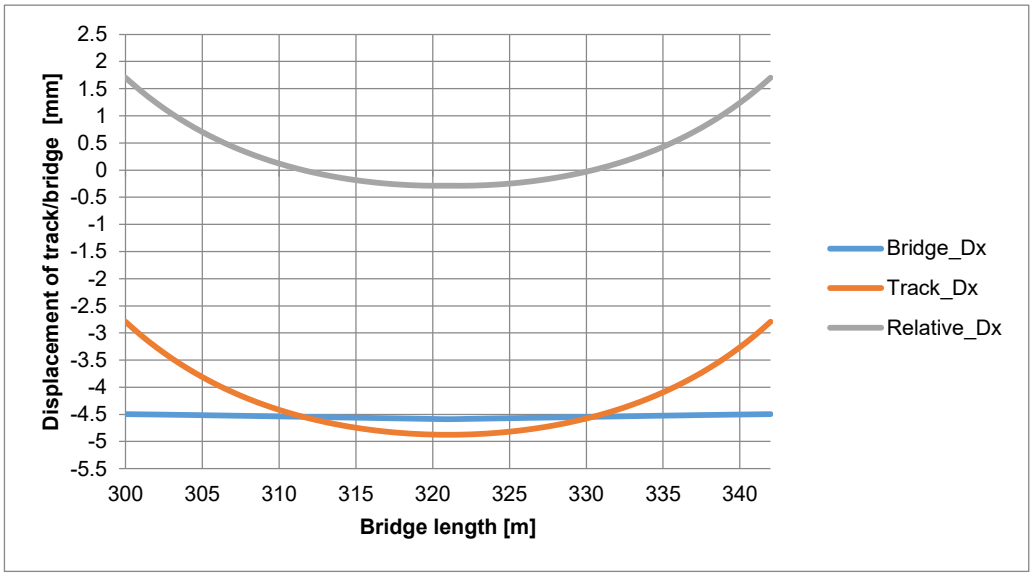
6) Relative horizontal displacement between rail and bridge superstructure due to acceleration/braking of the train

Left track (train braking)



Maximum relative horizontal displacement between rail and bridge superstructure due to braking of the train = **1,83 mm ≤ 4 mm**

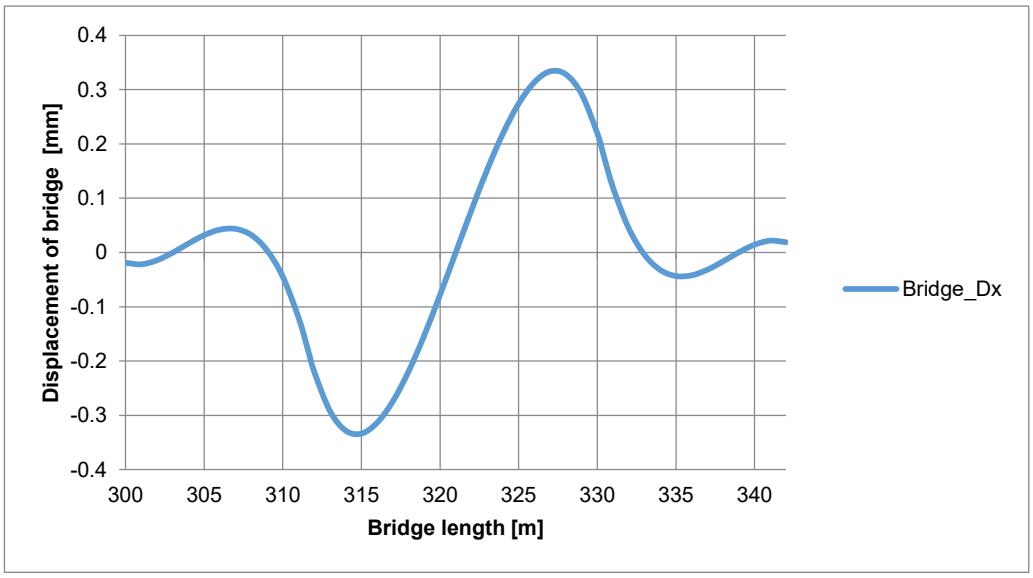
Right track (train acceleration)



Maximum relative horizontal displacement between rail and bridge superstructure due to acceleration of the train = **1,70 mm ≤ 4 mm**

7) Horizontal displacement of bridge superstructure due to rotating of bridge ends under the vertical load of the train

Left/Right bridge structure

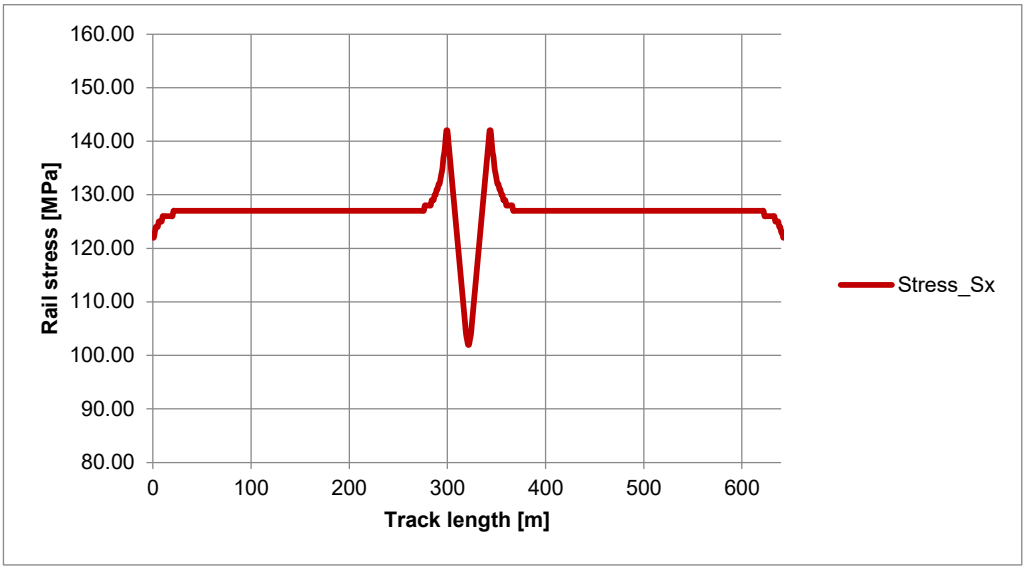


Maximum horizontal displacement of bridge superstructure due to rotating of bridge ends under the vertical load of the train = **0,02 mm < 8 mm**

1.2.1.6 Calculation of track-bridge interaction for winter climatic conditions

1) Rail stress due to temperature change in bridge superstructure and continuously welded rails

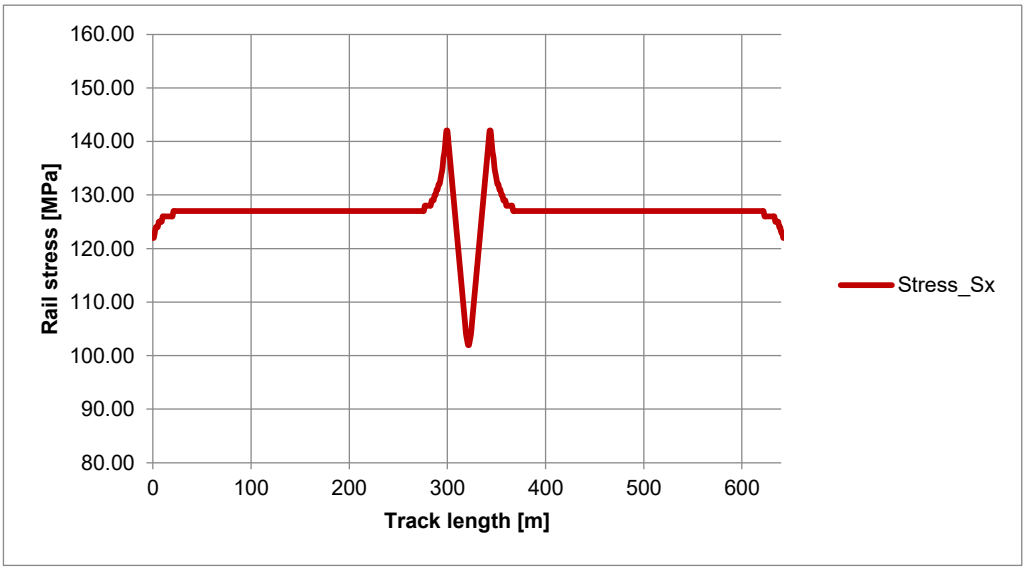
Left track



Maximum pressure stress in rail = **0,00 MPa**

Maximum tensile stress in rail = **+14,96 MPa**

Right track

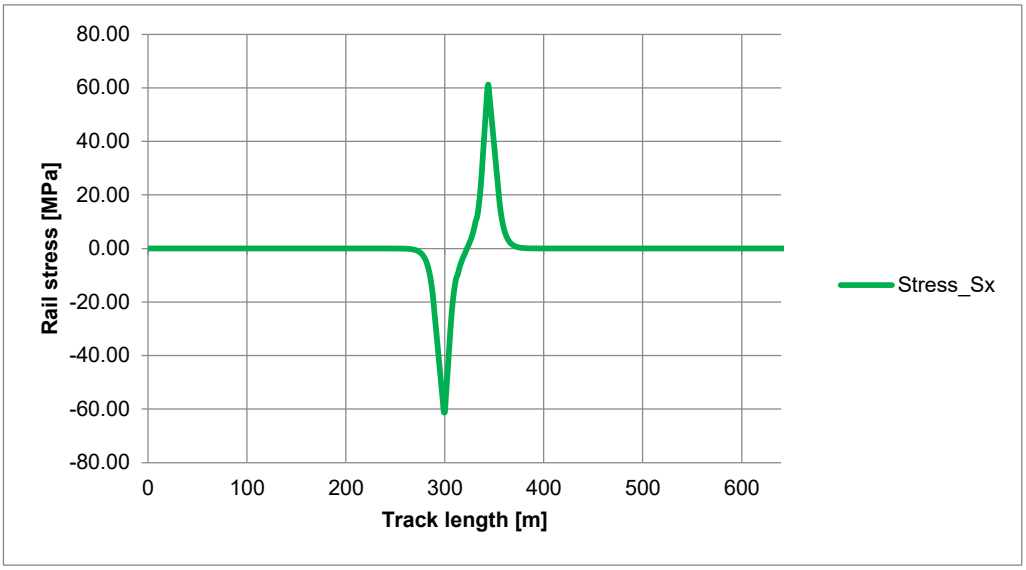


Maximum pressure stress in rail = **0,00 MPa**

Maximum tensile stress in rail = **+14,96 MPa**

2) Rail stress due to train acceleration/braking

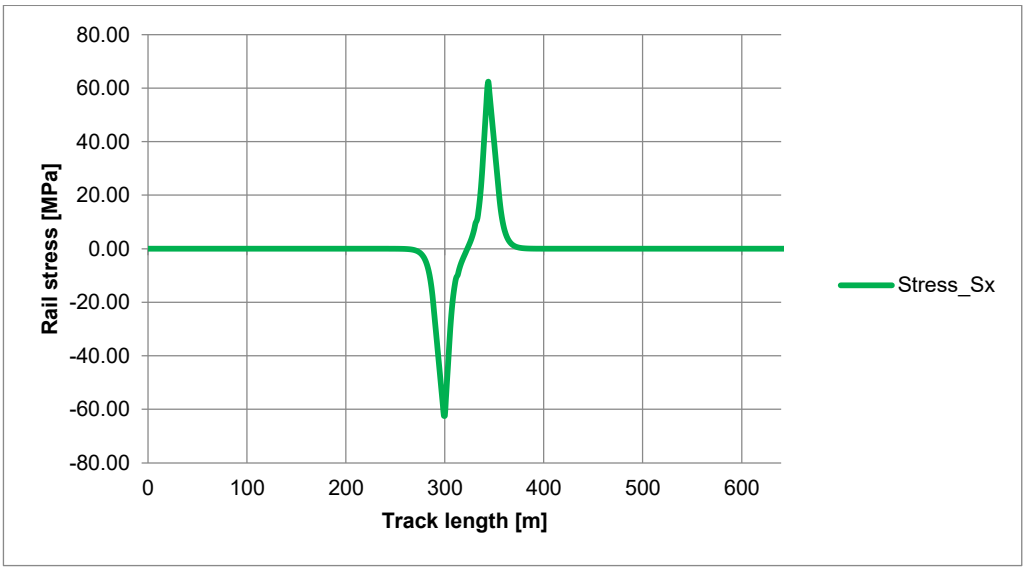
Left track (train braking)



Maximum pressure stress in rail = **0,00 MPa**

Maximum tensile stress in rail = **+61,22 MPa**

Right track (train acceleration)

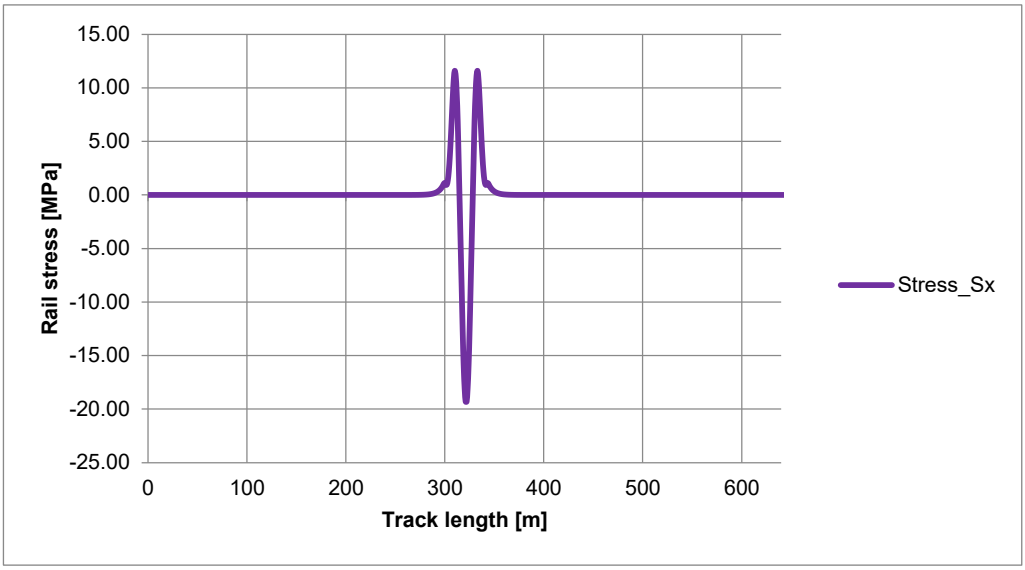


Maximum pressure stress in rail = **0,00 MPa**

Maximum tensile stress in rail = **+62,47 MPa**

3) Rail stress due to vertical bending under train

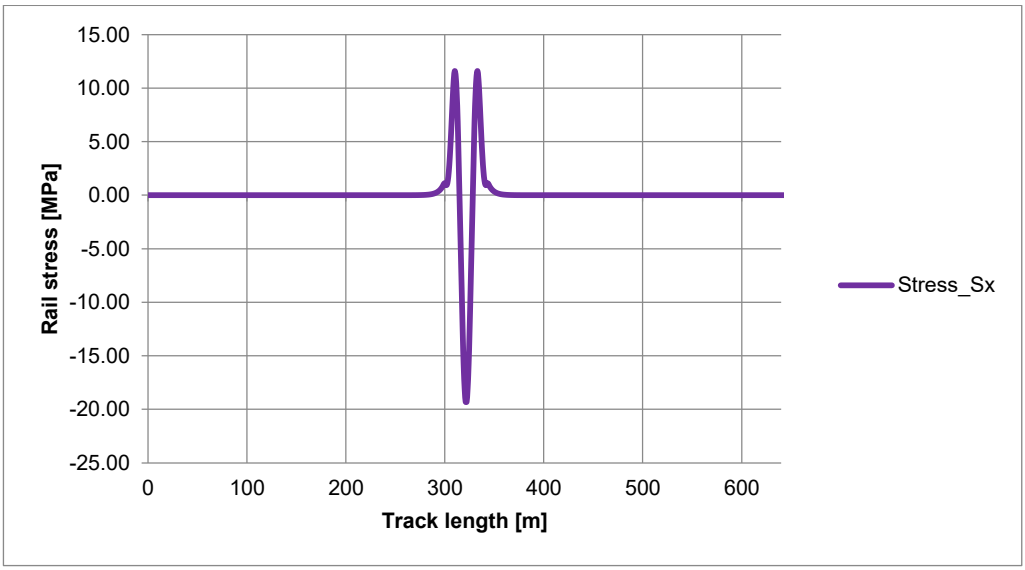
Left track



Maximum pressure stress in rail = **0,00 MPa**

Maximum tensile stress in rail = **+3,20 MPa**

Right track



Maximum pressure stress in rail = **0,00 MPa**

Maximum tensile stress in rail = **+3,20 MPa**

4) Rail stress due to temperature change in bridge superstructure, train acceleration/braking and vertical bending under train

Left track

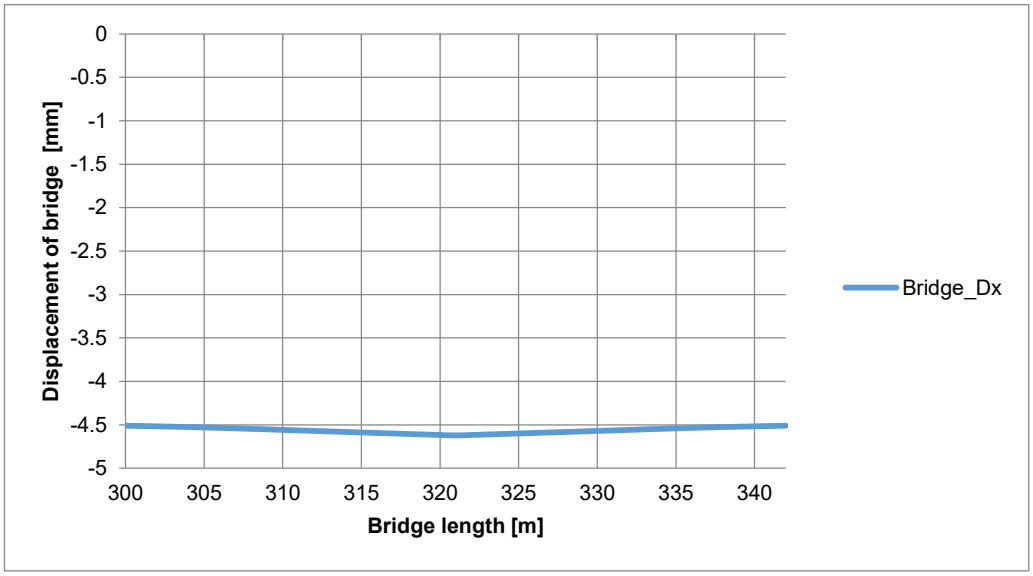
Maximum tensile stress in rail = **+14,96+61,22+3,20 = +79,38 MPa ≤ +92,00 MPa**

Right track

Maximum tensile stress in rail **= +14,96+62,47+3,20 = +80,63 MPa ≤ +92,00 MPa**

5) Absolute horizontal displacement of bridge superstructure due to acceleration/braking of the train

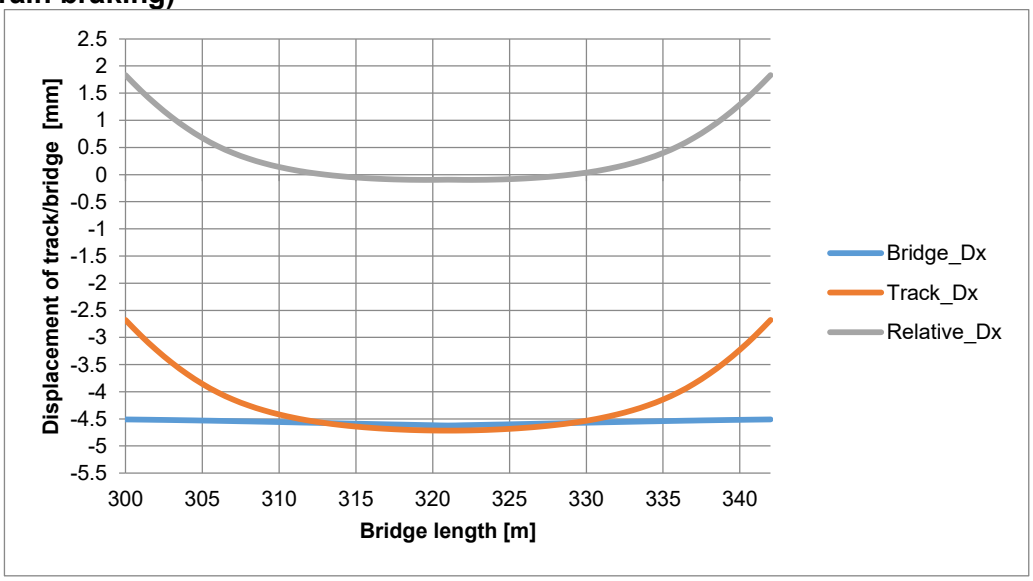
Left/Right bridge structure



Maximum absolute horizontal displacement of bridge superstructure due to acceleration/braking of the train = **4,62 mm ≤ 5 mm**

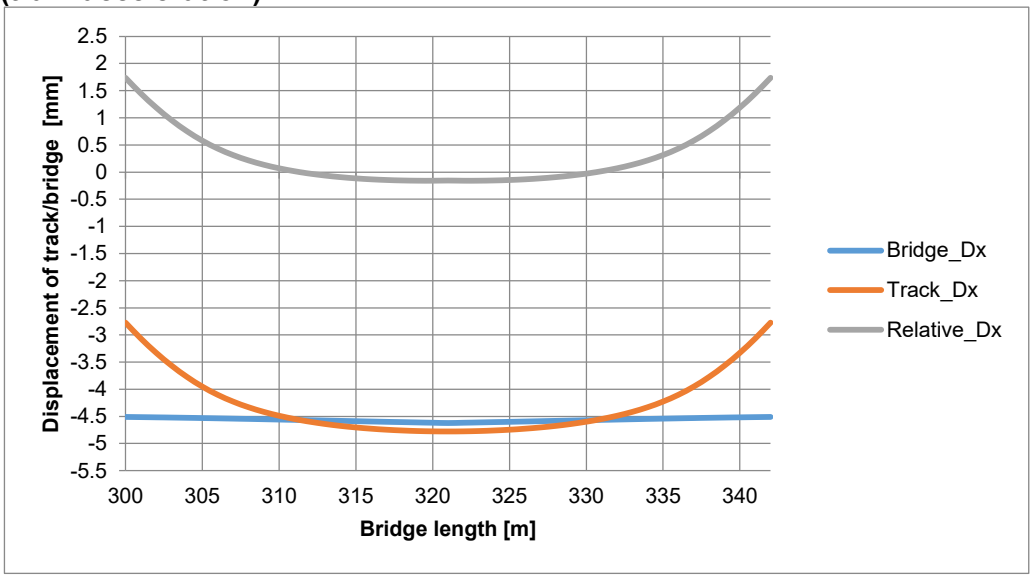
6) Relative horizontal displacement between rail and bridge superstructure due to acceleration/braking of the train

Left track (train braking)



Maximum relative horizontal displacement between rail and bridge superstructure due to braking of the train **= 1,83 mm ≤ 4 mm**

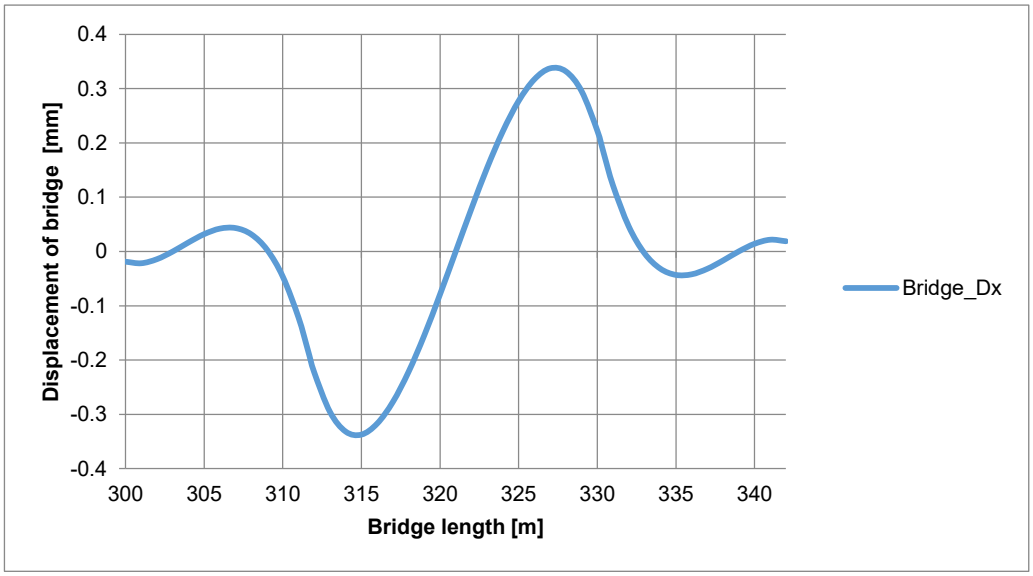
Right track (train acceleration)



Maximum relative horizontal displacement between rail and bridge superstructure due to acceleration of the train **= <u>1,74 mm ≤ 4 mm</u>**

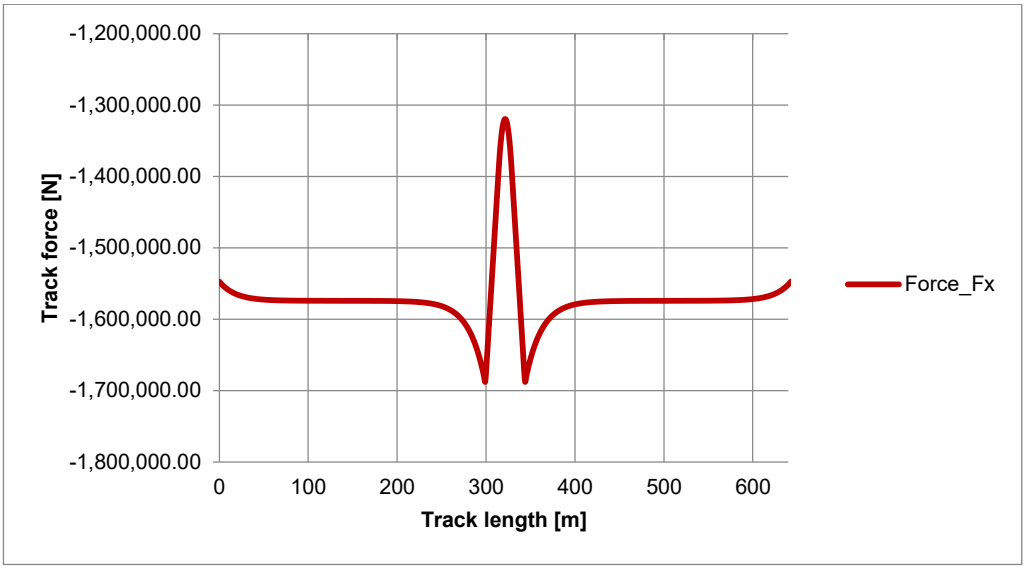
7) Horizontal displacement of bridge superstructure due to rotating of bridge ends under the vertical load of the train

Left/Right bridge structure



Maximum horizontal displacement of bridge superstructure due to rotating of bridge ends under the vertical load of the train = **<u>0,02 mm < 8 mm</u>**

1.2.1.7 Track stability in the horizontal plane on the bridge in summer climatic conditions

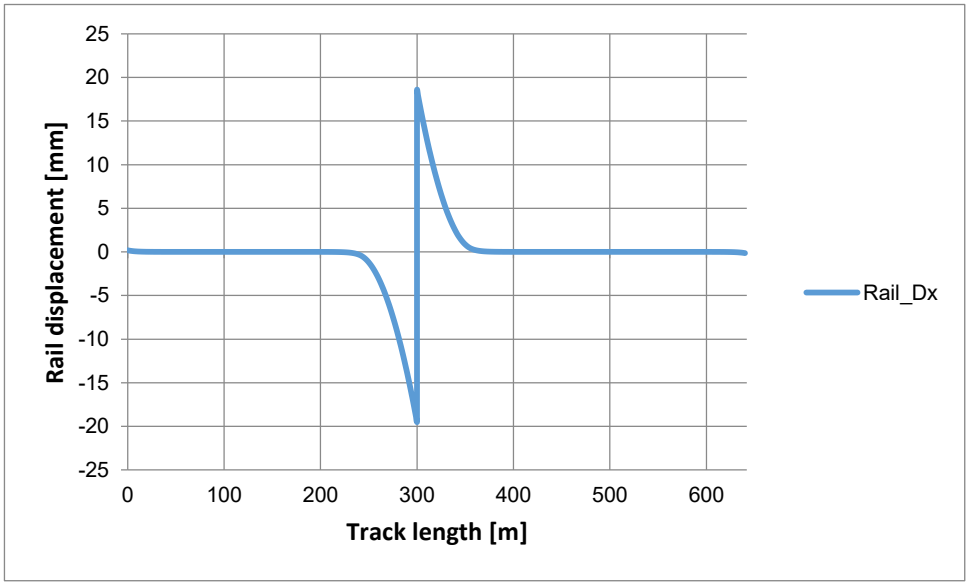


Maximum temperature pressure force in track on the bridge in summer climatic conditions relevant for the calculation of track stability in the horizontal plane = -1688070 N

The input parameters for the calculation of the track stability in the horizontal plane on the bridge in extreme summer climatic conditions are in accordance with Chapters 1.2.1.1, 1.2.1.2 and 1.2.1.3 as well as calculation results of the track/bridge interaction.

Checking the stability of the track in the horizontal plane was carried out for the maximum value of the pressure force in the track on the bridge -1688070 N.

1.2.1.8 Size of the rail gap on the bridge in winter climatic conditions



Maximum size of the gap due to cracking of the rail on the bridge in winter climatic conditions in the = **38,06 mm.**

Calculated by:
Zoran Lukovic,dipl.gradj.inz.
licenca broj 310 3032 03

2/2-6.1.6.6.3 CALCULATIONS OF VEHICLE/ TRACK/BRIDGE INTERACTION FOR BRIDGE AT KM 81+650.20 R.T. (81+644.83 L.T.)

CONTENT

1.1 Textual documentation

1.1.1 Technical report

1.1.1.1 Results of the calculation of the track-bridge interaction
1.1.1.2 Results of checking the stability of the track in the horizontal plane on the bridge
1.1.1.3 Results of checking the size of the rail gap on the bridge
1.1.1.4 Technical measures to ensure safety in case of derailment of the vehicle on the bridge

1.2 Numerical documentation

1.2.1 Static calculation

1.2.1.1 Input calculation parameters of the load
1.2.1.2 Input calculation parameters of the track
1.2.1.3 Input calculation parameters of the bridge
1.2.1.4 Calculation model of track-bridge interaction
1.2.1.5 Calculation of track-bridge interaction for summer climatic conditions
1.2.1.6 Calculation of track-bridge interaction for winter climatic conditions
1.2.1.7 Track stability in the horizontal plane on the bridge in summer climatic conditions
1.2.1.8 Size of the rail gap on the bridge in winter climatic conditions
1.2.1.9 Capacity of the rail expansion device in the track on the bridge

1.1 Textual documentation

1.1.1 Technical report

The calculation of the track-bridge interaction for the purpose of arranging the railway superstructure on the bridge at km 81+644.83 was performed in accordance with the requirements of the Technical Specifications of Interoperability for Infrastructure Subsystem (INF TSI).

Input design load parameters are harmonized with: Technical Specifications of Interoperability for Infrastructure Subsystem, as well as Serbian standards SRPS EN 1991-1-5, SRPS EN 1991-1-5/NA, SRPS EN 1991-2, SRPS EN 1991-2/NA.

In this sense, considered the following load due to:

- relevant temperature changes in the axis of the bridge deck and continuously welded rails,
- vertical load of the vehicle in accordance with the load scheme LM 71, SW/0, SW/2.
- horizontal load due to acceleration and/or braking of the vehicle.

All input calculation data in accordance with the bridge structure, railway superstructure, as well as railway vehicles are shown in Chapters 1.2.1.1, 1.2.1.2 and 1.2.1.3. In accordance with design speed of 180 km/h, a static calculation of the track-bridge interaction was performed. The calculation was performed using an integral model of track and bridge structures, with consideration of:

- bridge parameters: bridge disposition (static system, span, expansion length), geometrical characteristics of the bridge superstructure, stiffness and arrangement of bearings,
- track parameters: rail cross-section and rail steel quality, resistance to longitudinal displacement of unloaded and loaded track, taking into account bilinear behavior,
- load parameters: temperature change in the bridge superstructure, temperature changes in the continuously welded rails, acceleration/braking of vehicles, displacement and rotation of the ends of the bridge superstructure due to traffic load.

The connection between the track and the bridge superstructure was modeled using elastic connections with bilinear behavior. The horizontal stiffness of the supporting elements is defined in the model based on UIC 774-3 recommendations and standard SRPS EN 1991-2. In this way, the influences in the rails are obtained, which are relevant for comparison with the allowed additional stresses, proving the stability of the track in the horizontal plane for maximum summer temperatures, as well as gap size due to rail cracking for maximum winter temperatures. The calculation model takes into account the track with continuously welded rails at the length of the bridge and 300 m before and after the bridge, which corresponds to the maximum influential braking length of the vehicle. The layout of the calculation model is shown in Figures 9-11. A detailed description of the model characteristics is presented in Chapter 1.2.1.4.

1.1.1.1 Results of the calculation of the track-bridge interaction

Horizontal reactions on one (of a total of two) fix bridge bearing on the abutment due to the track-bridge interaction:

Type of load	Summer climatic conditions	Winter climatic conditions
Temperature change in axis of the bridge and continuously welded rails	**+1033,65 kN**	**-1034,20 kN**
Acceleration + Braking the train	**±708,45 kN**	**±685,25 kN**
Vertical load from the train	**-399,25 kN**	**-364,90 kN**
Note 1: The positive direction of the reaction corresponds to the direction of growth of the chainage. Note 2: The combined effect of temperature force, acceleration + braking force and the corresponding vertical load from the train is taken to dimensioning the bridge bearings and piers.		

Total horizontal reaction transmitted via shock absorbers (dampers) to the bridge abutment at km 81+721.85 due to the track-bridge interaction:

Type of load	Summer climatic conditions	Winter climatic conditions
Acceleration + Braking the train	**±1934,00 kN**	**±1546,80 kN**
Note 1: The positive direction of the reaction corresponds to the direction of growth of the chainage. Note 2: The acceleration + braking force is taken to dimensioning the bridge piers.		

Maximum additional compressive and tensile stresses in continuously welded rails:

Type of load	Left track	Right track
Summer climatic conditions		
Temperature change in axis of the bridge and continuously welded rails	0,00 MPa	0,00 MPa
Acceleration /Braking	-44,40 MPa	-35,60 MPa
Vertical load from the train	0,00 MPa	0,00 MPa
Total additional compressive/tensile stresses in the relevant sections of the continuously welded rail	**-44,40 MPa ≤ -72 MPa**	**-35,60 MPa ≤ -72 MPa**
Winter climatic conditions		
Temperature change in axis of the bridge and continuously welded rails	0,00 MPa	0,00 MPa
Acceleration /Braking	+60,70 MPa	+58,10 MPa
Vertical load from the train	+13,60 MPa	+13,60 MPa
Total additional compressive/tensile stresses in the relevant sections of the continuously welded rail	**+74,30 MPa ≤ +92 MPa**	**+71,70 MPa ≤ +92 MPa**
Note 1: Pressure stresses with sign (-), tensile stresses with sign (+)		

Maximum absolute and relative displacements of the track and the bridge superstructure:

Type of displacement	Summer climatic conditions	Winter climatic conditions
Absolute horizontal displacement of the bridge superstructure due to acceleration/braking of the train	**4,80 mm ≤ 5 mm**	**4,70 mm ≤ 5 mm**
Relative horizontal displacement between the rail and the bridge superstructure due to acceleration/braking of the train	**1,12 mm ≤ 4 mm (braking)** **1,52 mm ≤ 4 mm (acceleration)**	**1,18 mm ≤ 4 mm (acceleration)** **1,37 mm ≤ 4 mm (braking)**
Horizontal displacement due to rotating of the bridge ends under the vertical load from the train	**2,80 mm ≤ 8mm**	**2,80 mm ≤ 8mm**

1.1.1.2 Results of checking the stability of the track in the horizontal plane on the bridge

Input parameters for checking the stability of the track in the horizontal plane on the bridge at extreme summer temperatures in the rails and the bridge superstructure were adopted in accordance with Chapter 1.2.1.7 and based on the results of the calculation of the track-bridge interaction.

Checking the stability of the track in the horizontal plane was carried out for the maximum value of the pressure force in the track -1574280 N, which occurs in the transition zone from the embankment to the bridge due to the built-in expansion device in the tracks on the bridge.

1.1.1.3 Results of checking the size of the rail gap on the bridge

The calculation was performed under the assumption that the maximum longitudinal resistance during elastic displacement of the rail through the system of elastic rail fastening is 30 kN/m, which corresponds to the force of longitudinal resistance 9 kN.

The calculated value of the rail gap in winter conditions is approximately 46,32 mm.

1.1.1.4 Technical measures to ensure safety in case of derailment of the vehicle on the bridge

- The guard rails, to keep trains on the track in the event of derailment, must be installed, as they can provide safety at speeds up to 160 km/h. The role of the guard rails is to keep the vehicle on track if it derailment on the bridge. In that way, the structure of the bridge is protected from damage and other negative consequences of derailment are reduced (for example. the vehicle fell off the bridge after derailment). Guard rails are mounted on sleepers with a flat upper surface. Guard rails are extended by 10 m to the embankments before and after the bridge and are connected in the middle of the track.Since V_p = 180 km/h, it is necessary to ensure that the curb upper edge of the concrete bridge deck is 25 cm above the upper edge of the sleeper.

1.2 Numerical documentation

1.2.1 Static calculation

1.2.1.1 Input calculation parameters of the load

Input calculation parameters of load are harmonized with: Technical specifications of interoperability for subsystem of infrastructure, as well as Serbian standards SRPS EN 1991-1-5, SRPS EN 1991-1-5/NA, SRPS EN 1991-2, SRPS EN 1991-2/NA.

Temperature:

- temperature change in continuously welded rails in summer climatic conditions: +42,5 K,
- temperature change in continuously welded rails in winter climatic conditions: -52,5 K,
- temperature change in the bridge superstructure in summer climatic conditions: +49 K,
- temperature change in the bridge superstructure in winter climatic conditions: -44 K.

Vertical load from the train:

- LM71

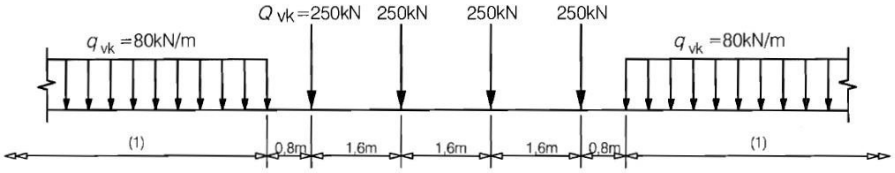
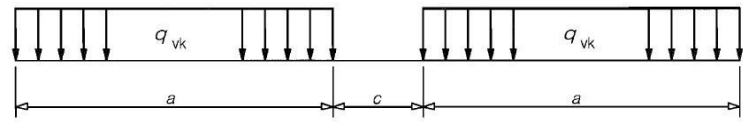


Fig. 2: Load model LM71 (α=1,21)

- SW/0, SW/2



Load Model	q_{vk} [kN/m]	a [m]	c [m]
SW/0	133	15,0	5,3
SW/2	150	25,0	7,0

Fig. 3: Load model SW/0, SW/2 (α=1,21 for SW/0)

Horizontal load from train acceleration/braking LM71, SW/0, SW/2:

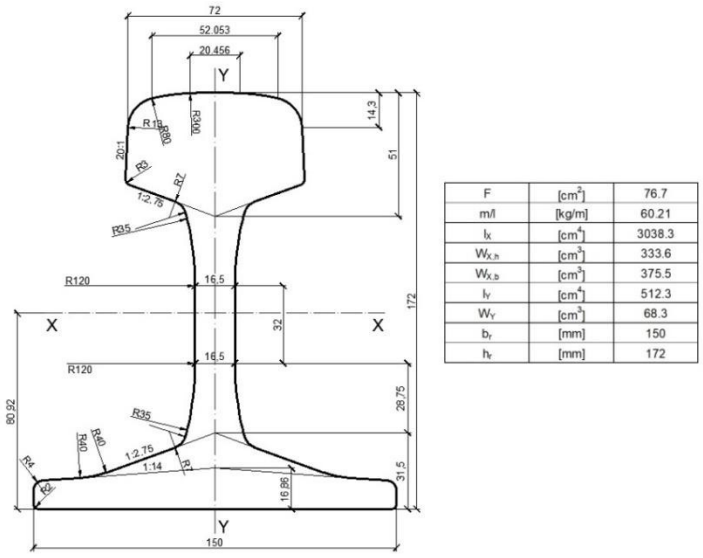
- train acceleration force 33 kN/m (≤1000 kN) for LM71, SW/0, SW/2 (α=1,21 for LM71, SW/0),
- train braking force 20 kN/m (≤6000 kN) for LM71, SW/0 (α=1,21),
- train braking force 35 kN/m for SW/2.

1.2.1.2 Input calculation parameters of the track

The input calculation parameters of the track are harmonized with: Serbian standards SRPS EN 13146-1, SRPS EN 13230 - parts 1 and 2, SRPS EN 13231, SRPS EN 13450, SRPS EN 13481 - parts 1 and 2, SRPS EN 13674-1, SRPS EN 1991-2, Law on the Safety of Railway Transport and Interoperability, as well as the Rulebook on Technical Conditions and Maintenance of the Railway Superstructure.

Rail

- rail cross-section 60E1 (tensile strength of steel 900 N/mm^2) in accordance with SRPS EN 13674-1,
- Young's modulus of elasticity of rail steel E=210 GPa,
- allowable additional tensile stress in rail foot 92 MPa in accordance with SRPS EN 1991-2,
- permissible additional pressure stress in rail 72 MPa in accordance with SRPS EN 1991-2,
- thermal expansion coefficient of rail steel α=1,15x10^{-5} 1/K.



F	[cm^2]	76.7
m/l	[kg/m]	60.21
I_X	[cm^4]	3038.3
$W_{X,h}$	[cm^3]	333.6
$W_{X,b}$	[cm^3]	375.5
I_Y	[cm^4]	512.3
W_Y	[cm^3]	68.3
b_r	[mm]	150
h_r	[mm]	172

Fig. 4: Rail cross-section 60E1 with geometric characteristics

Elastic rail fastening systems

For concrete sleepers in accordance with a series of Serbian standards SRPS EN 13481 - parts 1 and 2 and SRPS EN 13146-1.

- minimum longitudinal resistance to rail displacement ≥ 7 kN (calculated with 9 kN) in accordance with SRPS EN 13674-1,

Mono block prestressed concrete sleepers with a flat top surface

In accordance with a series of Serbian standards SRPS EN 13481-2 and SRPS EN 13230 - parts 1 and 2.

- minimum sleeper mass 281 kg without rail fastening,
- sleeper length 260 cm,
- longitudinal axial distance between sleepers 60 cm,
- minimum active backing surface of sleeper on ballast 0,57 m^2.

Rail expansion device

Rail expansion device is projected at km 81+721.85 in both tracks.

Ballast prism of gravel

In accordance with a series of Serbian standards SRPS EN 13450 with the dimensions of the ballast prism according to SRPS EN 13231.

- the minimum thickness of the ballast prism on the bridge below the lower edge of the sleeper in the cross-section below the rail 35 cm,
- width of the shoulder part of the ballast prism on the concrete deck of the bridge > 50 cm,
- resistance of the ballast prism to the longitudinal displacement of the unloaded track k=20 kN/m in accordance with SRPS EN 1991-2,
- resistance of the ballast prism to the longitudinal displacement of the loaded track k=60 kN/m in accordance with SRPS EN 1991-2.

1.2.1.3 Input calculation parameters of the bridge

The input design parameters of the bridge are defined in accordance with the characteristics of the bridge structure.

- the bridge is a continuous girder static system with spans along the longitudinal axis of the bridge 49 m + 56 m + 49 m,
- the bridge superstructure consists of a steel truss structure with a coupled concrete deck on the lower chord of the truss,
- steel truss structure is constructed from steel grade S355,
- concrete deck is made of concrete class C35/45,
- the support of bridge superstructure is done over 12 bearings, 4 on each abutment, and 2 on each middle pier,
- shock absorbers (dampers) to accept the impact due to braking/acceleration of the railway vehicle are placed on the bridge abutment at km 81+721.85,

- the required minimum longitudinal (horizontal) stiffness of the supports of bridge superstructure due to acceleration/braking train is ≥ 450000 kN/m,
- the expansion length of the bridge is L_T=154 m,
- bridge is straight,
- on the bridge there is double track of railway in curve R=2000 m designed for speed V_p=180 km/h,
- the maximum permissible longitudinal relative displacement between the continuously welded rail and the bridge superstructure due to acceleration/braking of the train is ≤ 4 mm,
- the maximum permissible longitudinal absolute displacement of the bridge superstructure due to acceleration/braking of the train is ≤ 5 mm,
- the maximum permissible longitudinal displacement of the bridge superstructure due to the rotation of the ends of the bridge superstructure under the vertical load from the train is ≤ 8 mm.

Longitudinal section

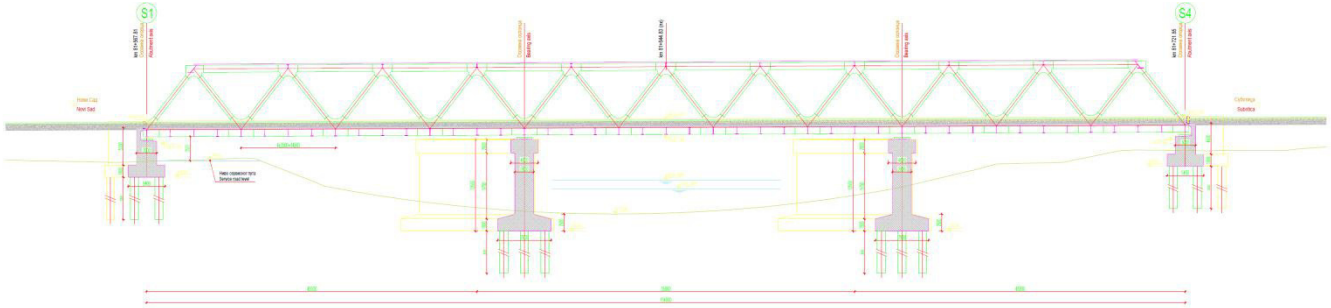


Fig. 5: Longitudinal section of the bridge on km 81+644.83

Cross-section

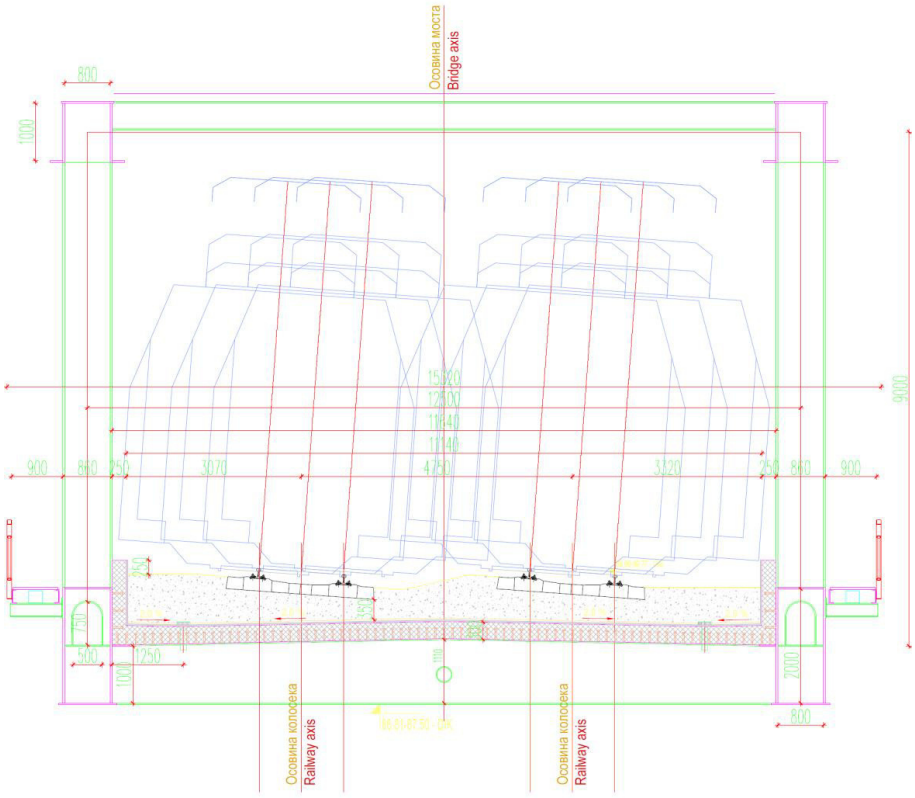


Fig. 6: Cross-section of the bridge on km 81+644.83

Bearing scheme

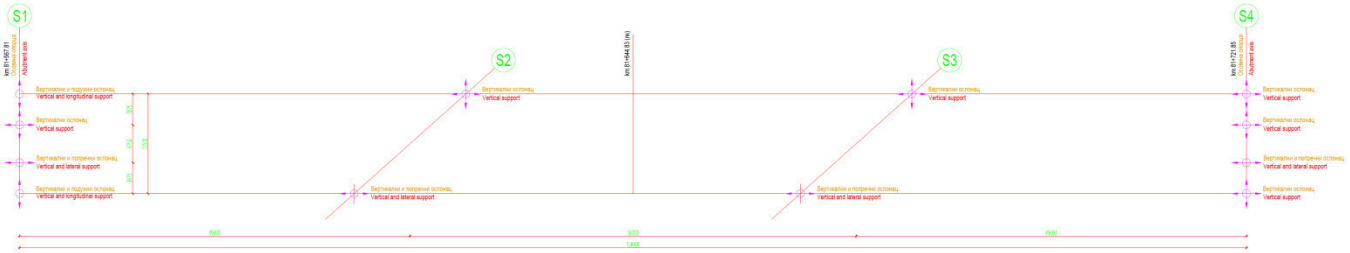
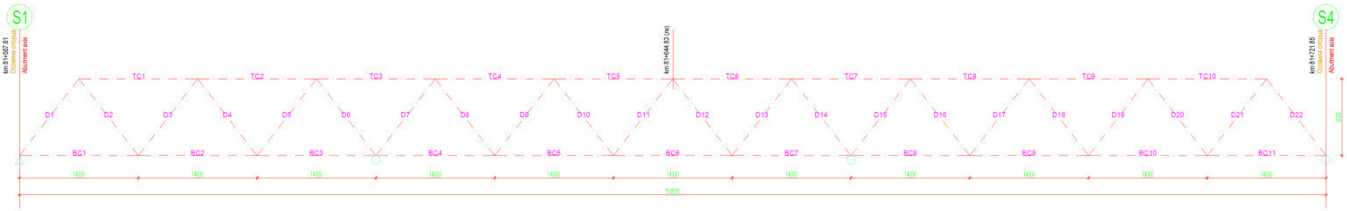


Fig. 7: Bearing scheme of bridge on km 81+644.83

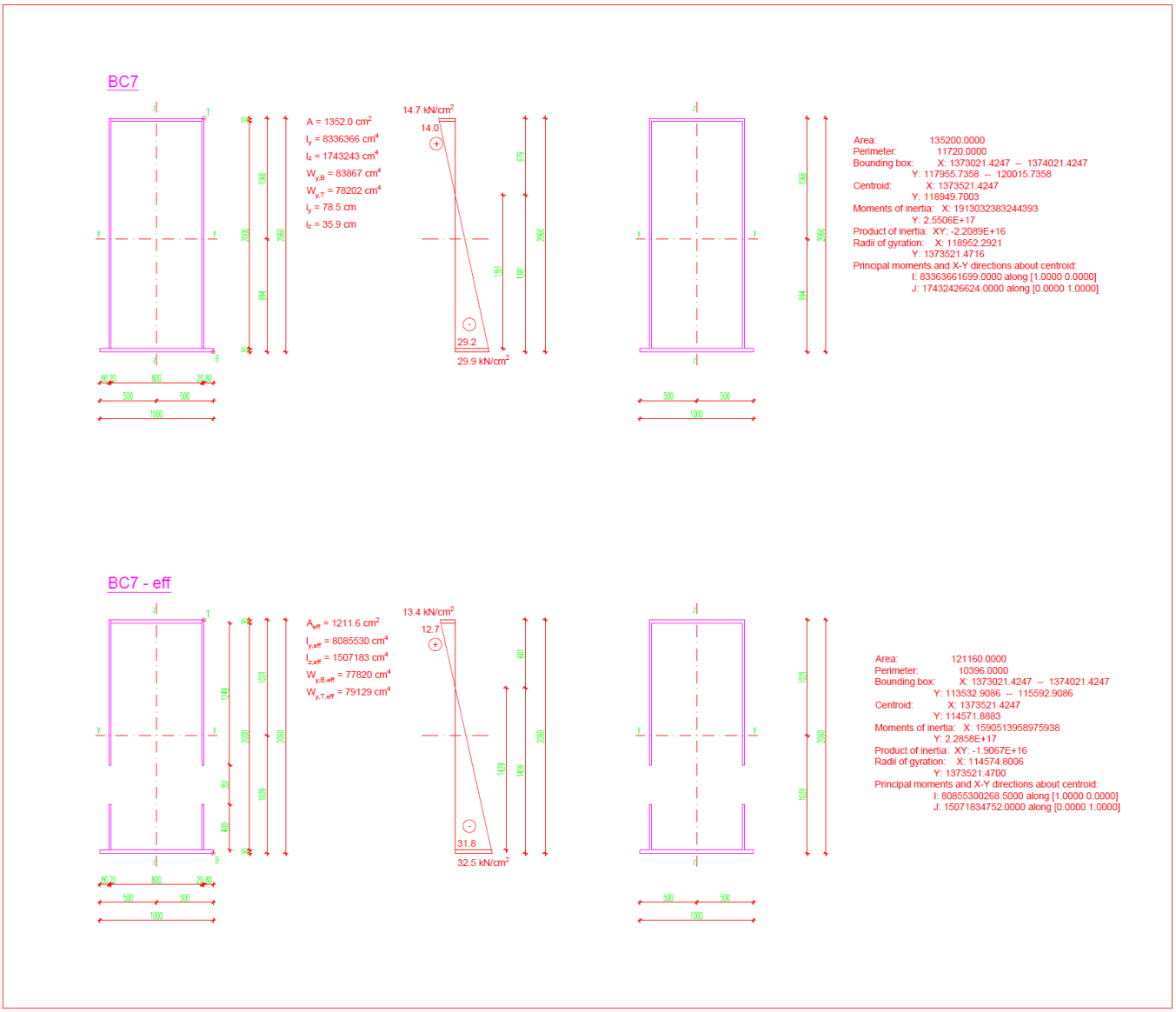
Geometrical characteristics of elements bridge superstructure

Steel truss structure with coupling concrete deck:



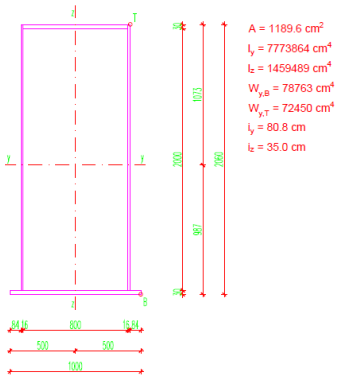
- Elements of steel truss structure [mm]

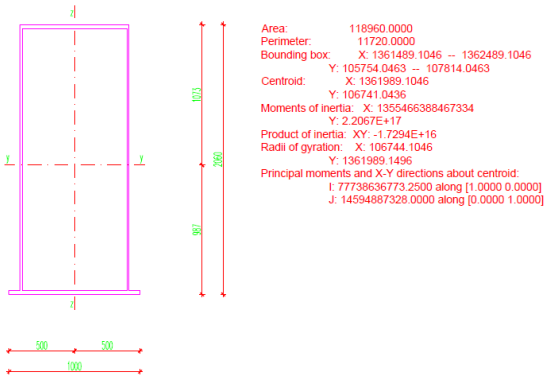
BC3, BC4, BC7, BC8



BC1, BC2, BC5, BC6, BC9, BC10, BC11

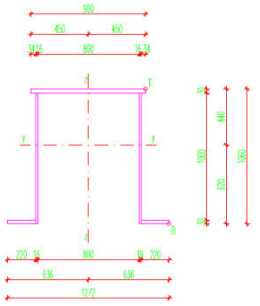
BC10

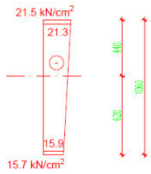


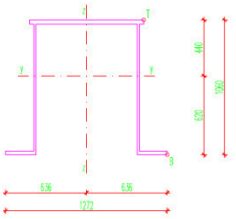


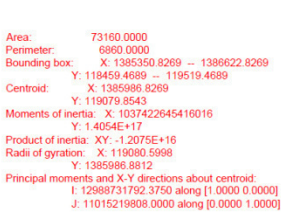
TC1, TC2, TC4, TC5, TC6, TC8, TC9, TC10

TC9

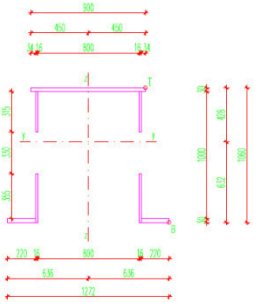


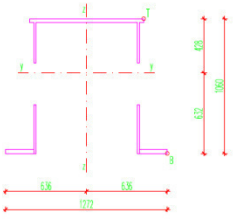


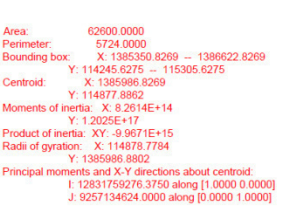




TC9 - eff

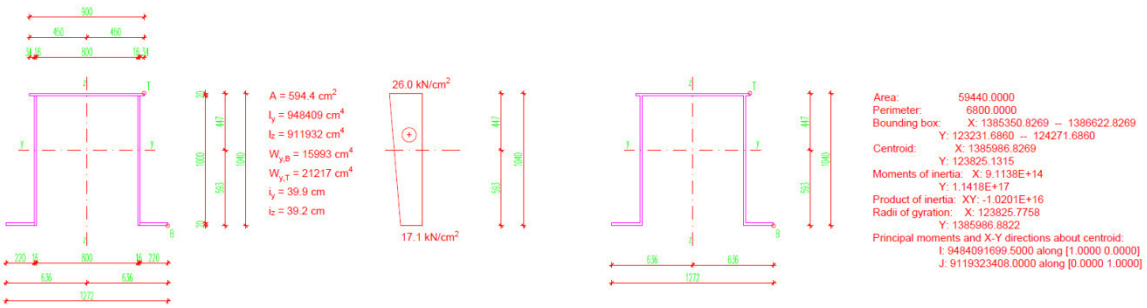






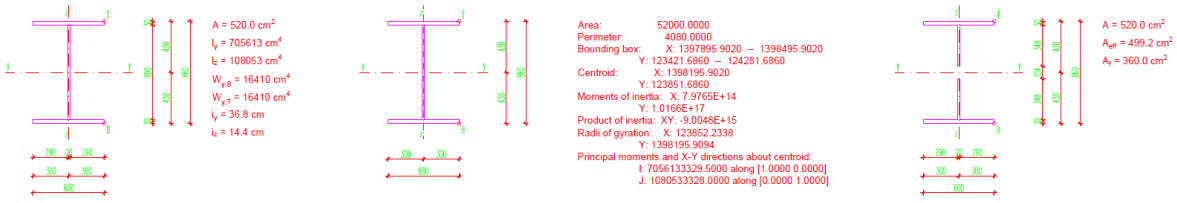
TC7, TC3

TC7



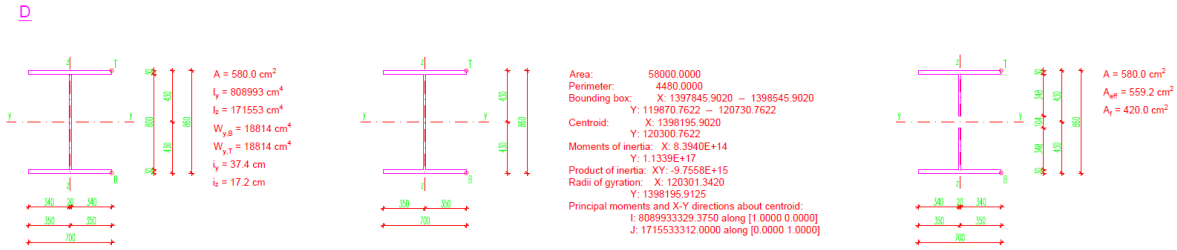
Type 1 - D2, D3, D4, D9, D10, D11, D12, D18, D19, D20

D



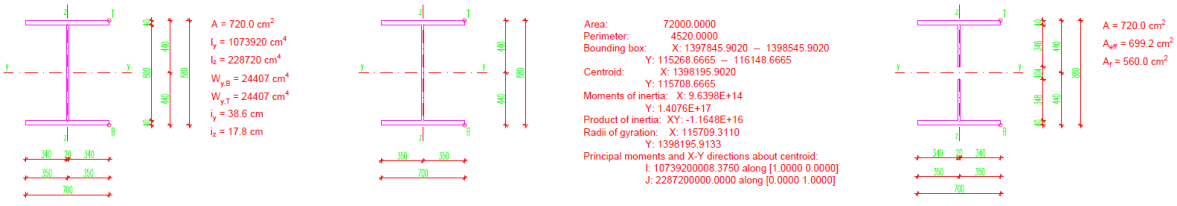
Type 2 - D5, D8, D17, D21

D

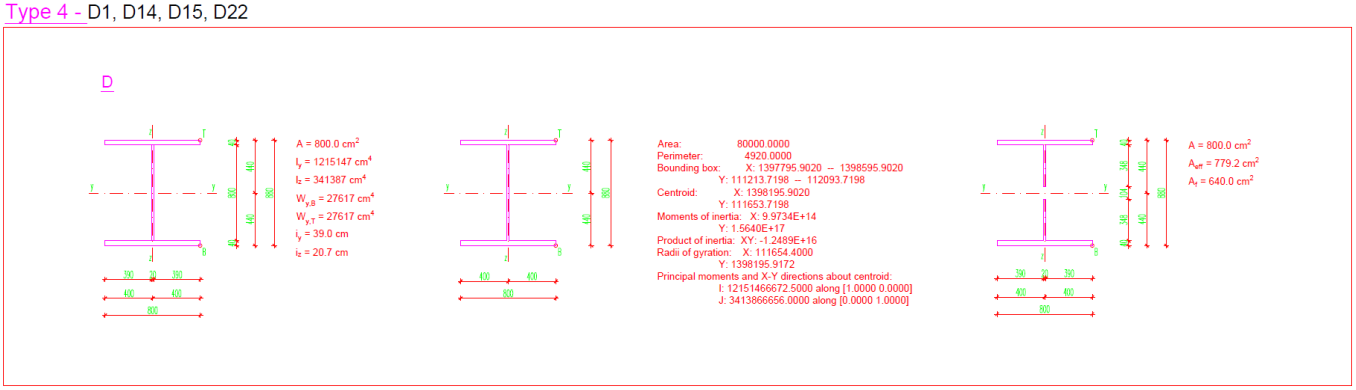


Type 3 - D6, D7, D13, D16

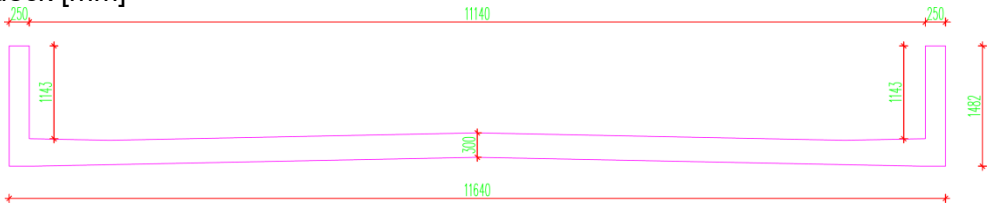
D



Type 4 - D1, D14, D15, D22



- Concrete deck [mm]



Material characteristics of the elements bridge superstructure

All elements of the steel truss structure are made of steel grade S355 with the following characteristics:

Steel grade S355:

- $E=2,1x10^{8}$ kN/m^2
- v=0,3
- $\alpha=1,2x10^{-5}$ 1/C
- $\rho=76,98$ kN/m^3

Concrete deck is made of concrete class C35/45 with the following characteristics:

Concrete class C35/45:

- $E= 3,4077x10^{7}$ kN/m^2 ($Er=9,33x10^{6}$ kN/m^2 - reduced value of cracked concrete with reinforcement)
- v=0,2
- $\alpha=1,0x10^{-5}$ 1/C
- $\rho=25,00$ kN/m^3

Steel reinforcement in the concrete is grade B500B:

Steel reinforcement grade B500B:

- $E=2,1x10^{8}$ kN/m^2
- v=0,3
- $\alpha=1,2x10^{-5}$ 1/C
- $\rho=78,00$ kN/m^3

1.2.1.4 Calculation model of track-bridge interaction

Based on the calculation of the track-bridge interaction, the influences are obtained in the following form:

- longitudinal forces in supports (reactions of fixed supports),
- additional stresses in rails,
- absolute and relative displacements of the rails and the bridge superstructure.

Influences due to interaction are determined iteratively, by a series of nonlinear simulations, in order to determine the behavior of the track-bridge system, due to temperature changes in the bridge superstructure, vertical load from the train and longitudinal forces due to train acceleration/braking.

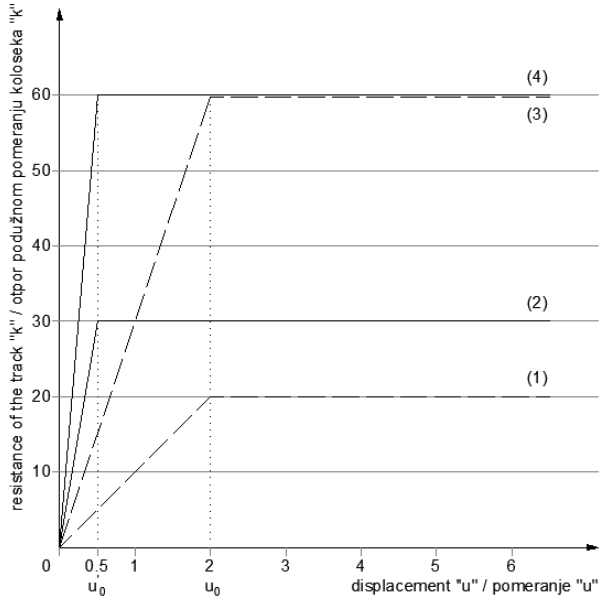
The calculation of the track-bridge interaction is carried out using an integral model of track and bridge structure taking into account:

- bridge parameters: bridge disposition (static system, spans, expansion lengths), geometrical characteristics of the bridge superstructure, stiffness of structure and arrangement of supports,
- track parameters: rail cross-section and rail steel quality, resistance to longitudinal displacement of loaded and unloaded track, taking into account the bilinear behavior of the track-bridge connection,

- load parameters: temperature changes in the bridge superstructure and rails, acceleration and braking of the train, displacement and rotating the ends of the bridge super structure due to traffic load.

The connection between the track elements and the bridge superstructure elements was modeled by means of elastic connections with bilinear behavior in accordance with the Serbian standard SRPS EN 1991-2 (Figure 8).

The model adopts the horizontal stiffness of the fixed support, which corresponds to the real displacement of the bridge superstructure due to acceleration/braking the train. In this way, the influences in the rails are obtained, which are relevant for the analysis of the allowed additional stresses and track stability in the horizontal plane at maximum summer temperature, as well as the size of the gap when the rail cracks at maximum winter temperature. The calculation model takes into account the track with continuously welded rails at a length of 300 m in before and after the bridge, which corresponds to the maximum influential length of train braking.



(1) - resistance of sleeper in ballast (unloaded track)
otpor podužnom pomeranju praga kroz zastor (neopterećen kolosek)

(2) - resistance of rail in sleeper (unloaded track) (frozen ballast or track without ballast)
otpor podužnom pomeranju šine u odnosu na prag (neopterećen kolosek) (smrznuti zastor ili kolosek na čvrstoj podlozi)

(3) - resistance of sleeper in ballast (loaded track)
otpor podužnom pomeranju praga kroz zastor (opterećen kolosek)

(4) - resistance of rail in sleeper (loaded track) (frozen ballast or track without ballast)
otpor podužnom pomeranju šine u odnosu na prag (opterećen kolosek) (smrznuti zastor ili kolosek na čvrstoj podlozi)

u'_0 - ultimate relative displacement of the rail to the sleeper
granično relativno pomeranje šine u odnosu na prag

u_0 - ultimative relative displacement of the sleeper in the ballast
granično relativno pomeranje praga u odnosu na zastor

Note: / Napomena:
rail profile 60E1, concrete sleepers B70 at a distance of 60 cm and longitudinal resistance of the rail in the track 2x9 kN, minimum thickness of the compacted ballast below the sleeper is 30 cm.
šine 60E1, betonski pragovi B70 na razmaku 60 cm i podužni otpor šina u koloseku 2x9 kN, minimalna debljina zbijenog zastora ispod praga 30 cm.

Fig. 8: Longitudinal displacement resistance of track/rail

View of calculation model

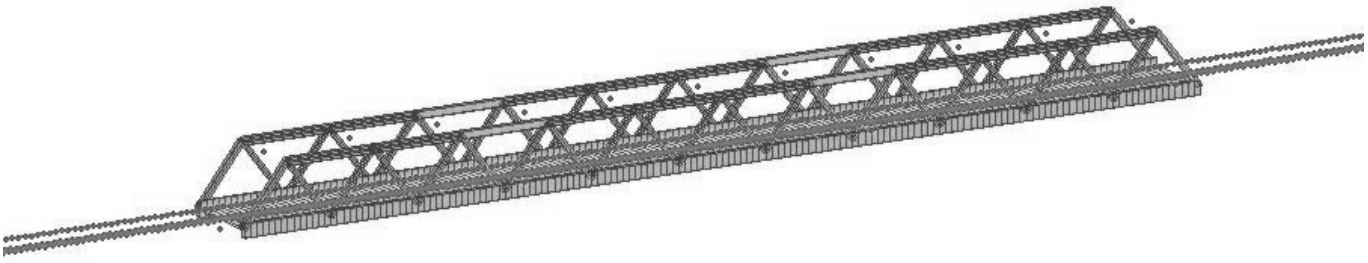


Fig. 9: View of calculation model

Longitudinal section of the calculation model

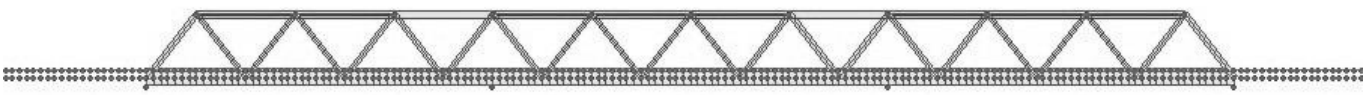


Fig. 10: Longitudinal section of the calculation model

Cross-section of calculation model

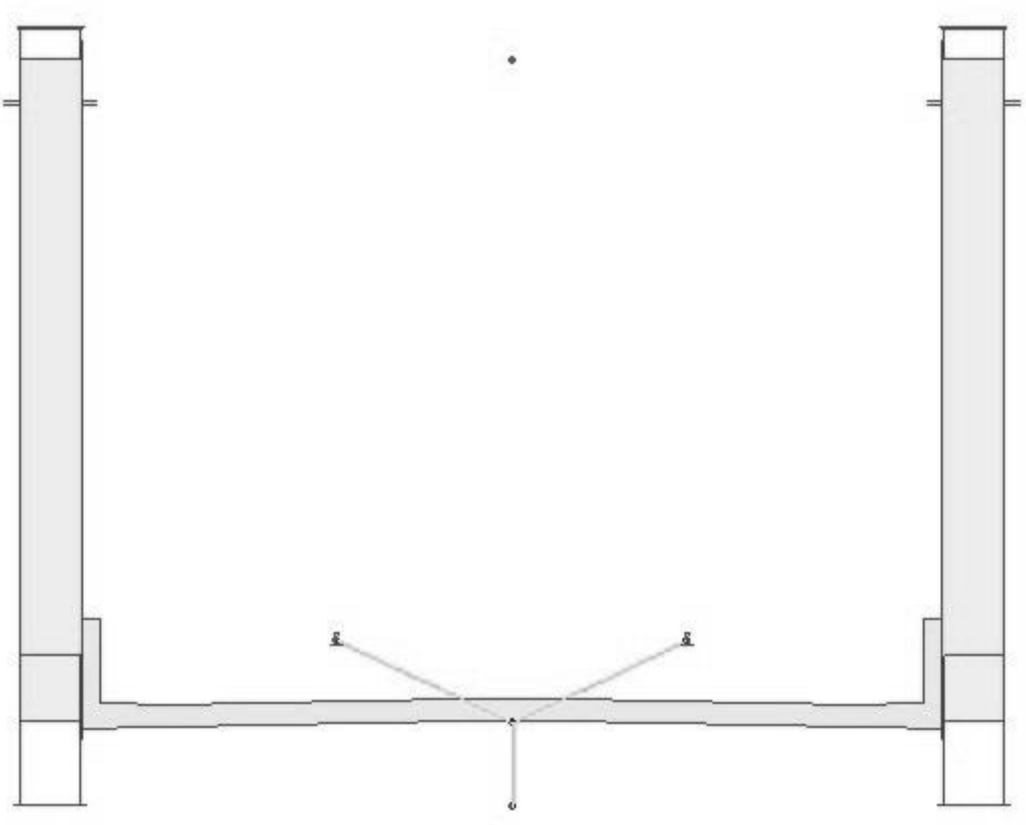
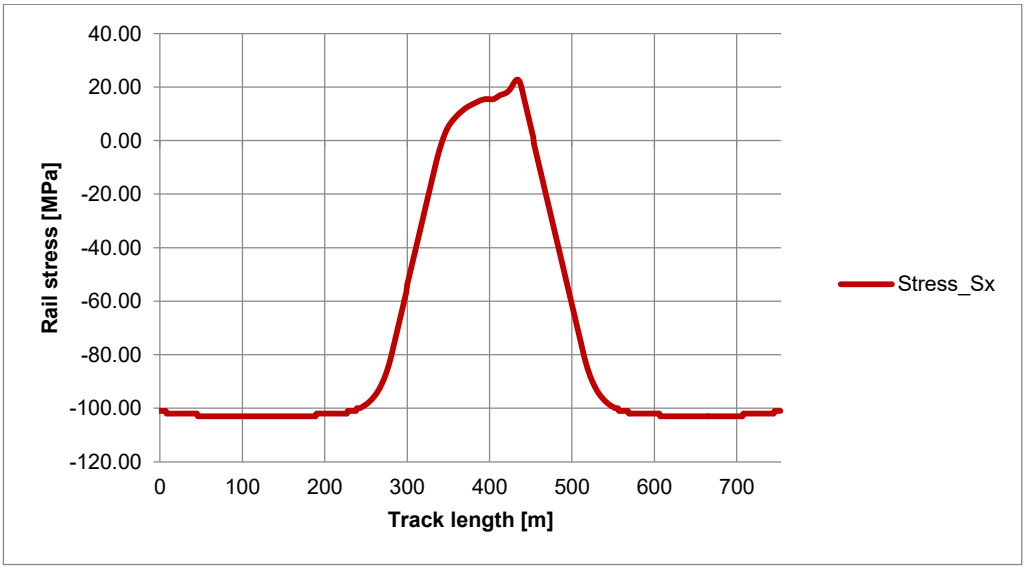


Fig. 11: Cross-section of the calculation model with elastic connections with bilinear behavior between the track and the bridge superstructure

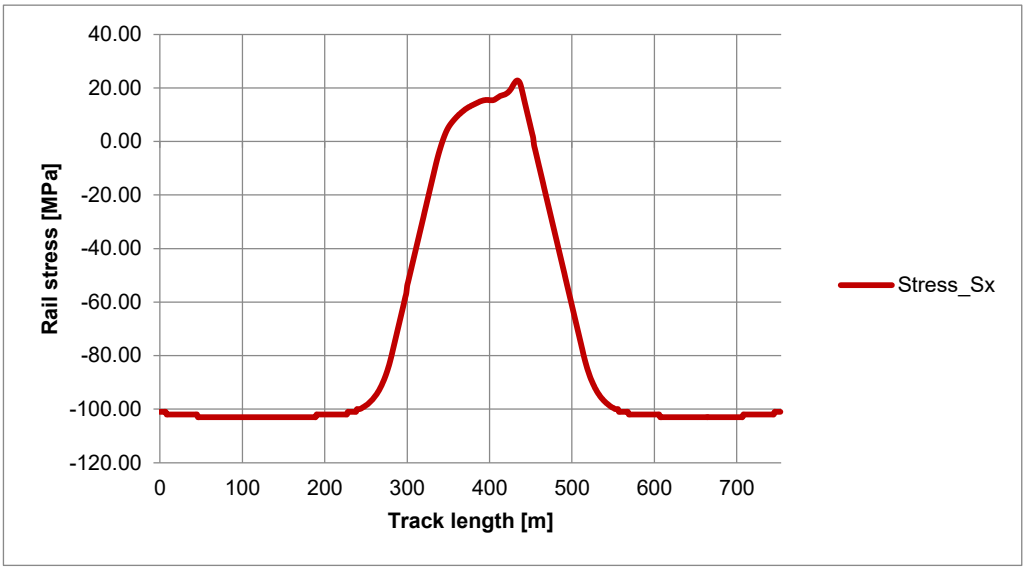
1.2.1.5 Calculation of track-bridge interaction for summer climatic conditions

1) Rail stress due to temperature change in bridge superstructure and continuously welded rails
Left track



Maximum pressure stress in rail = **-56,60 MPa (the additional pressure stress is equal to zero)**
Maximum tensile stress in rail = **0,00 MPa**

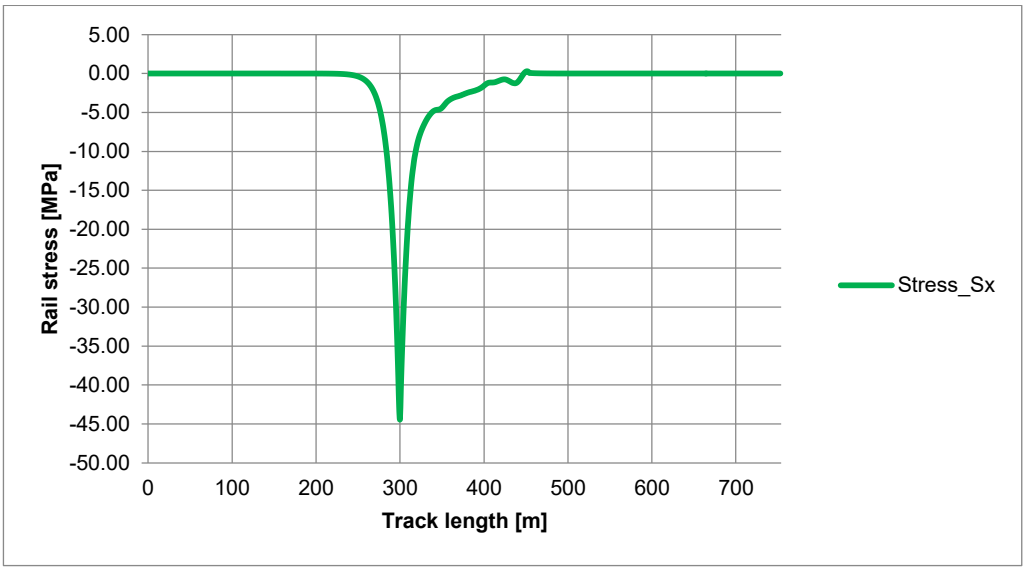
Right track



Maximum pressure stress in rail = **-56,60 MPa (the additional pressure stress is equal to zero)**
Maximum tensile stress in rail = **0,00 MPa**

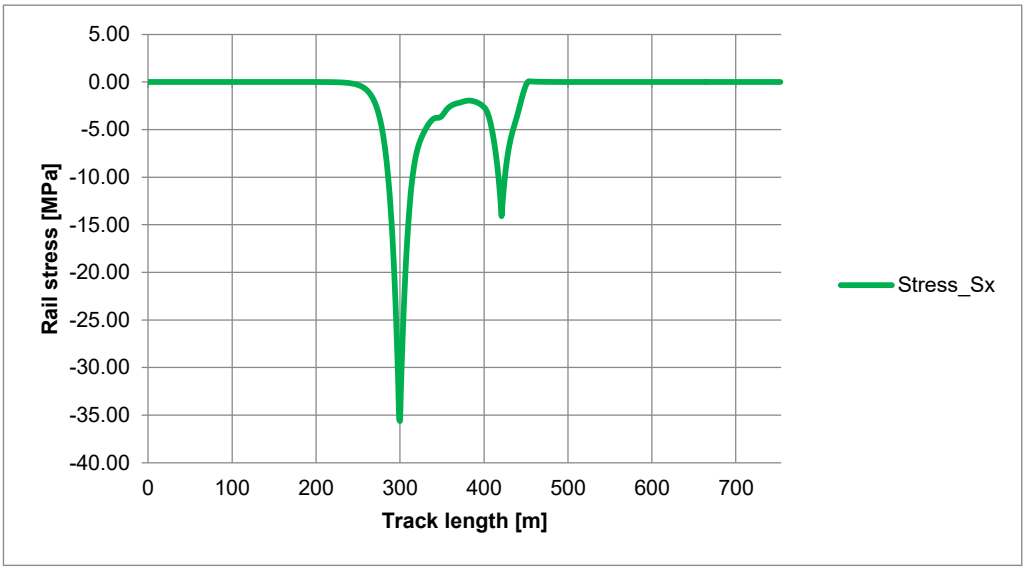
2) Rail stress due to train acceleration/braking

Left track (train braking)



Maximum pressure stress in rail = **-44,40 MPa**
Maximum tensile stress in rail = **0,00 MPa**

Right track (train acceleration)

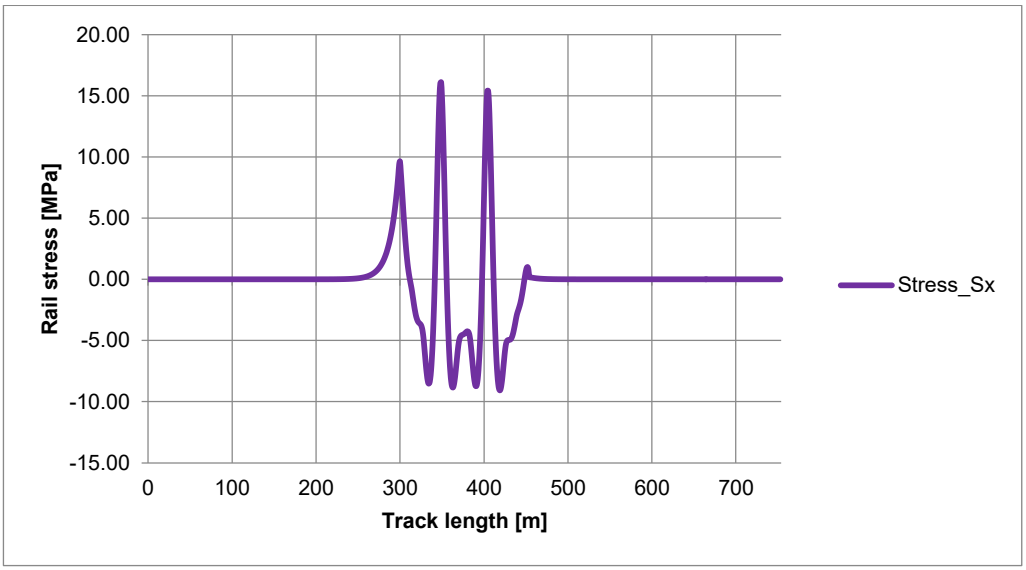


Maximum pressure stress in rail = **-35,60 MPa**

Maximum tensile stress in rail = **0,00 MPa**

3) Rail stress due to vertical bending under train

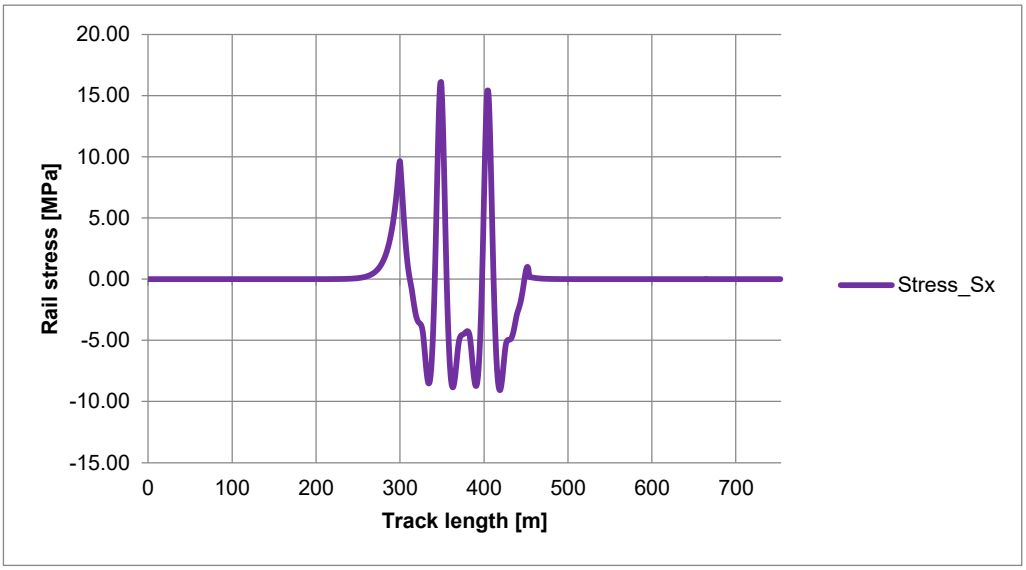
Left track



Maximum pressure stress in rail = **0,00 MPa**

Maximum tensile stress in rail = **+9,63 MPa**

Right track



Maximum pressure stress in rail = **0,00 MPa**

Maximum tensile stress in rail = **+9,63 MPa**

4) Rail stress due to temperature change in bridge superstructure, train acceleration/braking and vertical bending under train

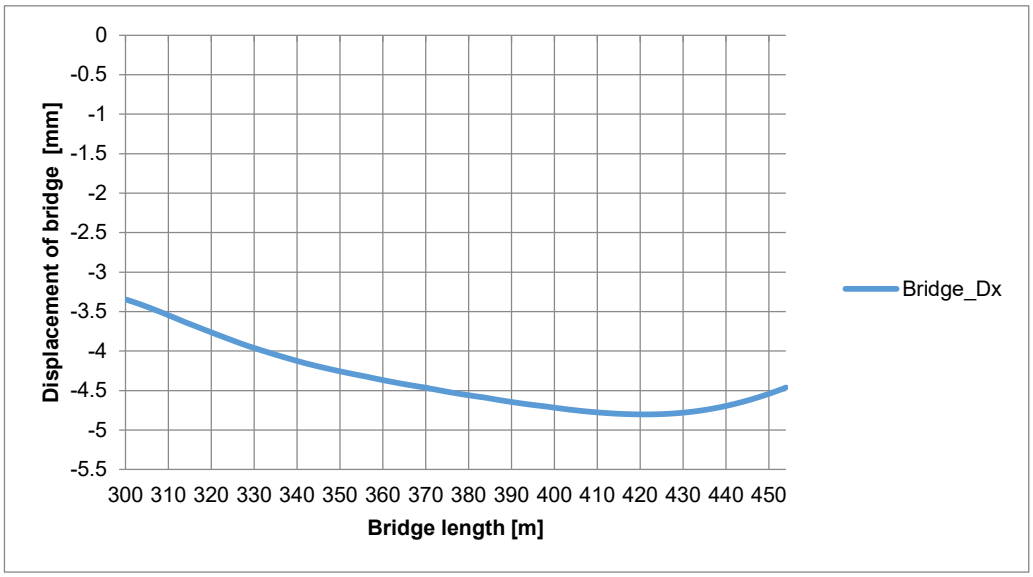
Left track

Maximum pressure stress in rail = **-0,00-44,40-0,00 = -44,40 MPa ≤ -72,00 MPa**

Right track

Maximum pressure stress in rail = **-0,00-35,60-0,00 = -35,60 MPa ≤ -72,00 MPa**

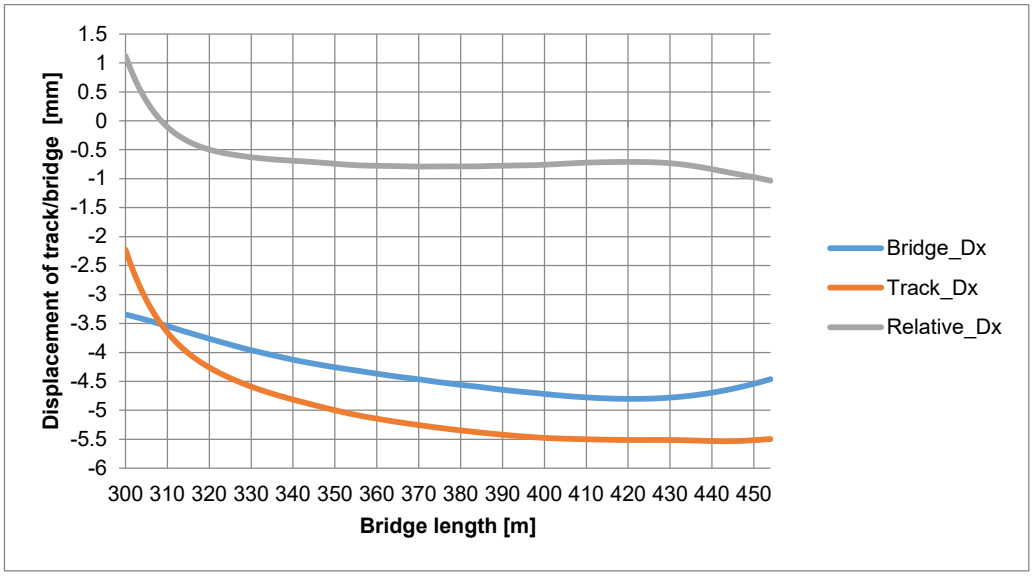
5) Absolute horizontal displacement of bridge superstructure due to acceleration/braking of the train



Maximum absolute horizontal displacement of bridge superstructure due to acceleration/braking of the train = **4,80 mm ≤ 5 mm**

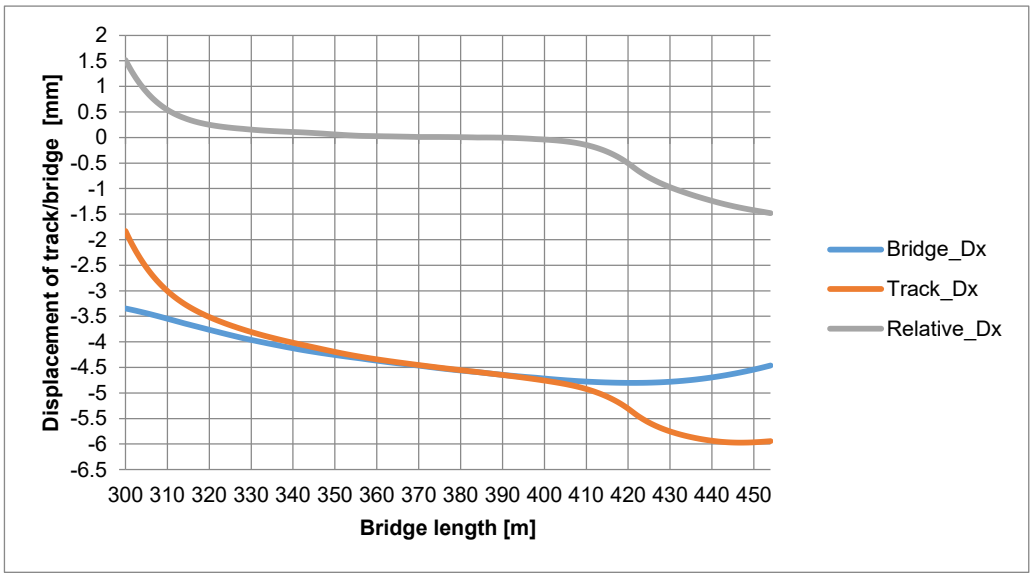
6) Relative horizontal displacement between rail and bridge superstructure due to acceleration/braking of the train

Left track (train braking)



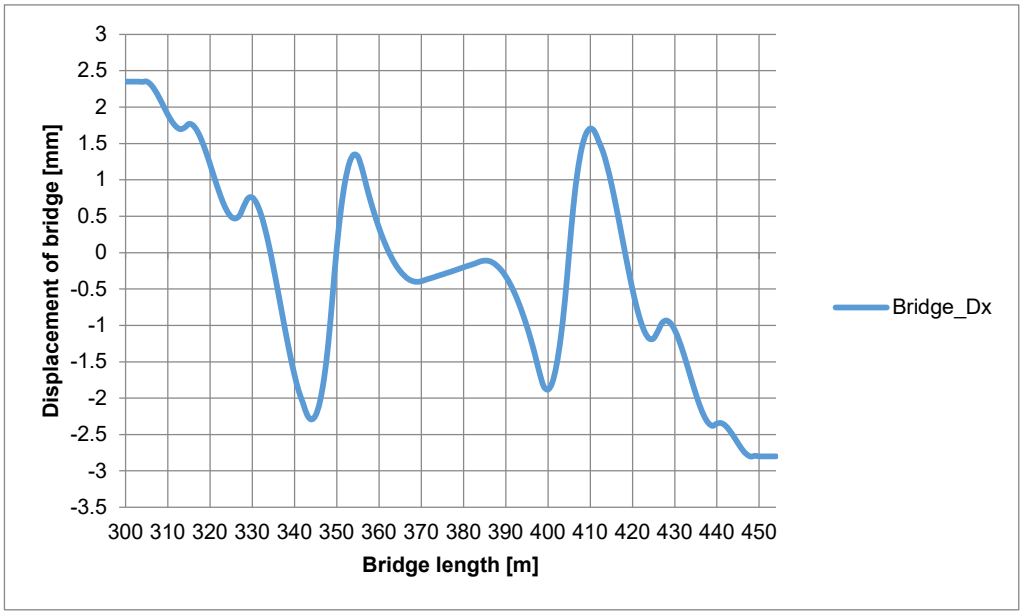
Maximum relative horizontal displacement between rail and bridge superstructure due to braking of the train = **1,12 mm ≤ 4 mm**

Right track (train acceleration)



Maximum relative horizontal displacement between rail and bridge superstructure due to acceleration of the train = **1,52 mm ≤ 4 mm**

7) Horizontal displacement due to rotating of the bridge ends under the vertical load from the train

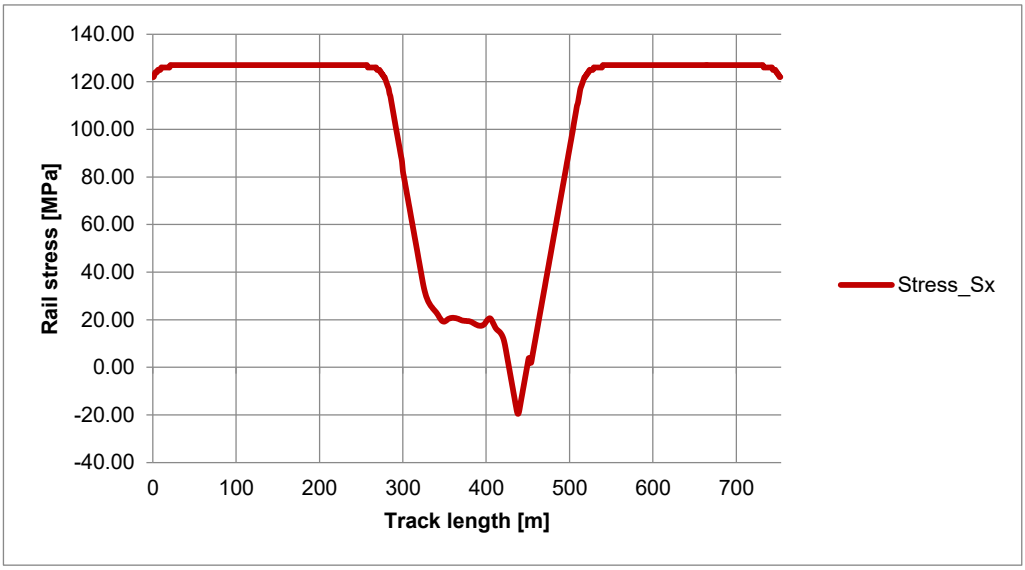


Maximum horizontal displacement due to rotating of the bridge ends under the vertical load from the train = **2,80 mm < 8 mm**

1.2.1.6 Calculation of track-bridge interaction for winter climatic conditions

1) Rail stress due to temperature change in bridge superstructure and continuously welded rails

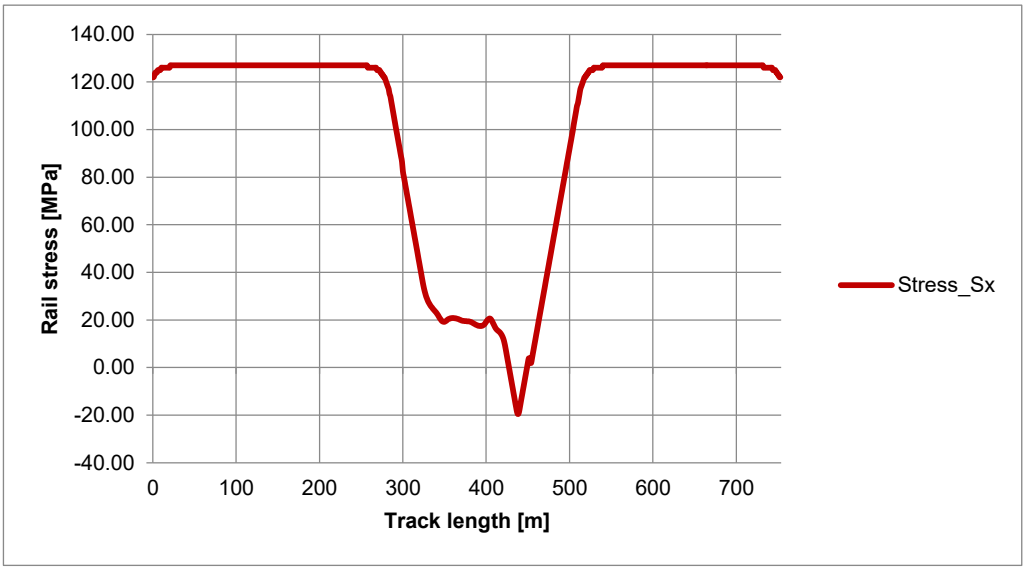
Left track



Maximum pressure stress in rail = **0,00 MPa**

Maximum tensile stress in rail = **+86,40 MPa (the additional tensile stress is equal to zero)**

Right track

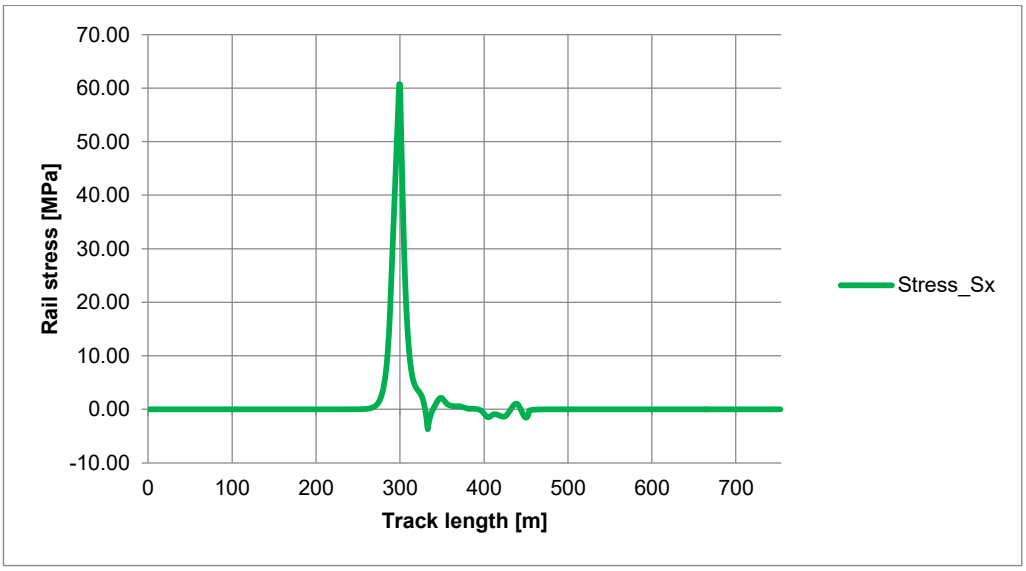


Maximum pressure stress in rail = **0,00 MPa**

Maximum tensile stress in rail = **+86,40 MPa (the additional tensile stress is equal to zero)**

2) Rail stress due to train acceleration/braking

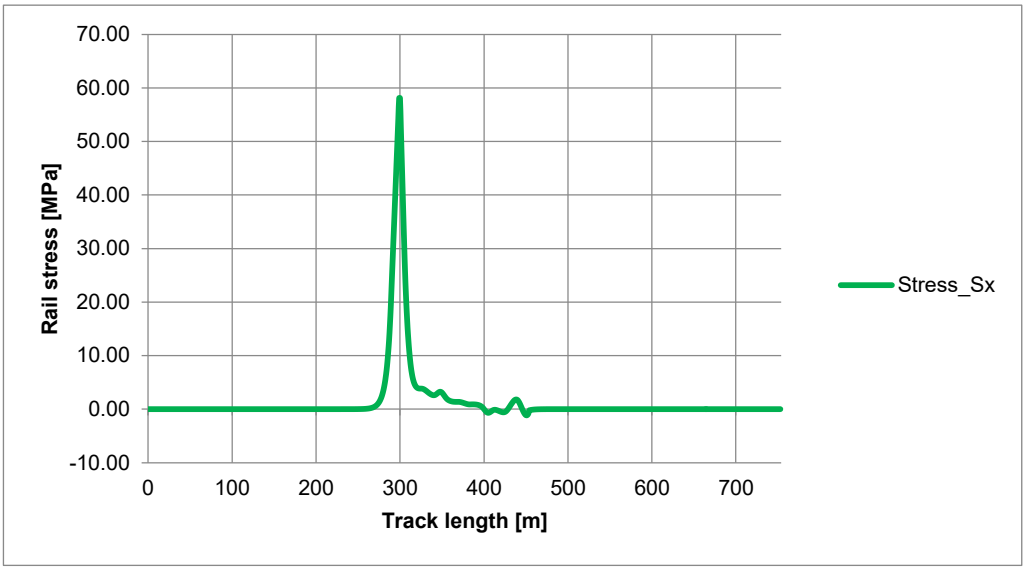
Left track (train acceleration)



Maximum pressure stress in rail = **0,00 MPa**

Maximum tensile stress in rail = **+60,70 MPa**

Right track (train braking)

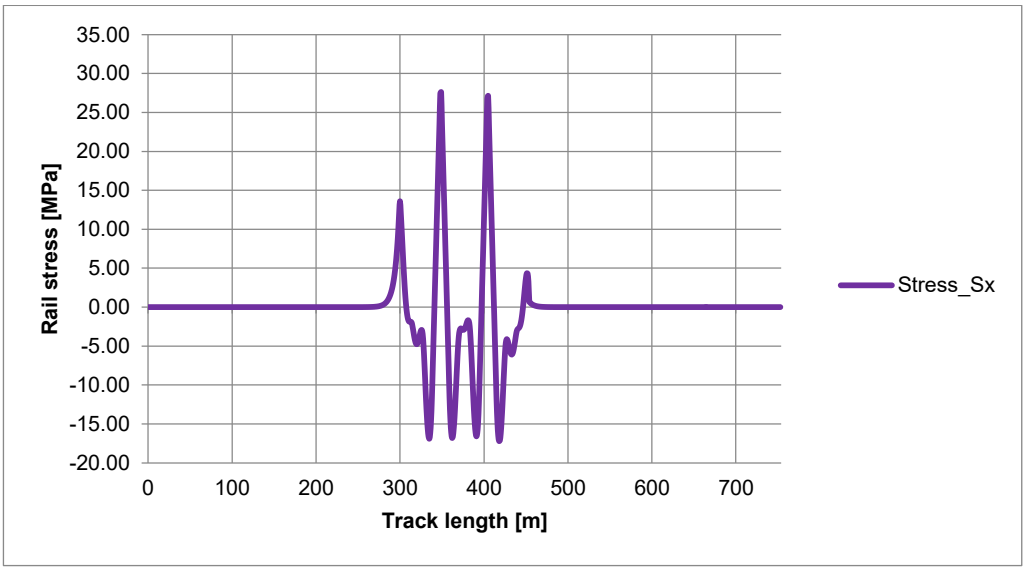


Maximum pressure stress in rail = **0,00 MPa**

Maximum tensile stress in rail = **+58,10 MPa**

3) Rail stress due to vertical bending under train

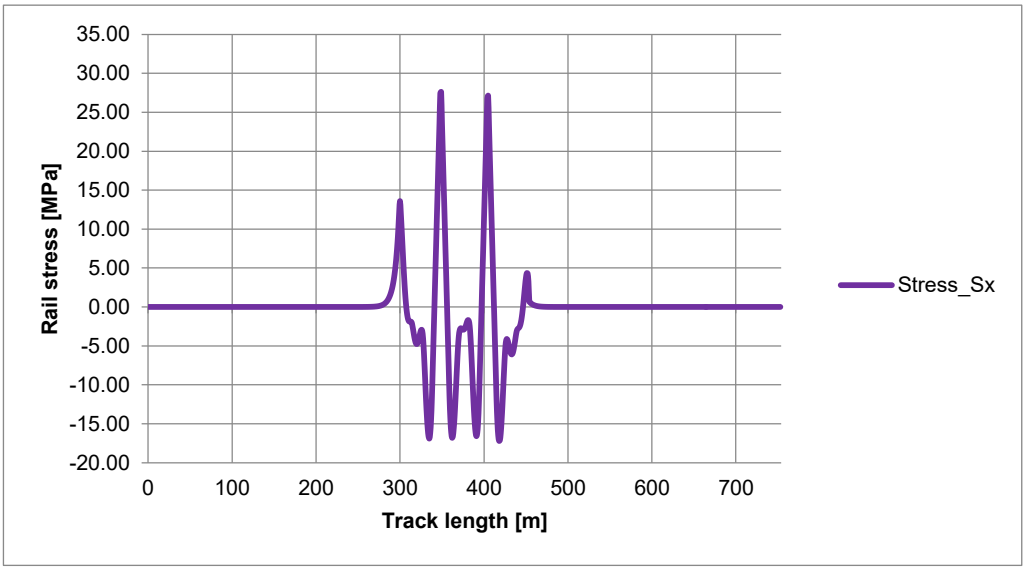
Left track



Maximum pressure stress in rail = **0,00 MPa**

Maximum tensile stress in rail = **+13,60 MPa**

Right track



Maximum pressure stress in rail = **0,00 MPa**

Maximum tensile stress in rail = **+13,60 MPa**

4) Rail stress due to temperature change in bridge superstructure, train acceleration/braking and vertical bending under train

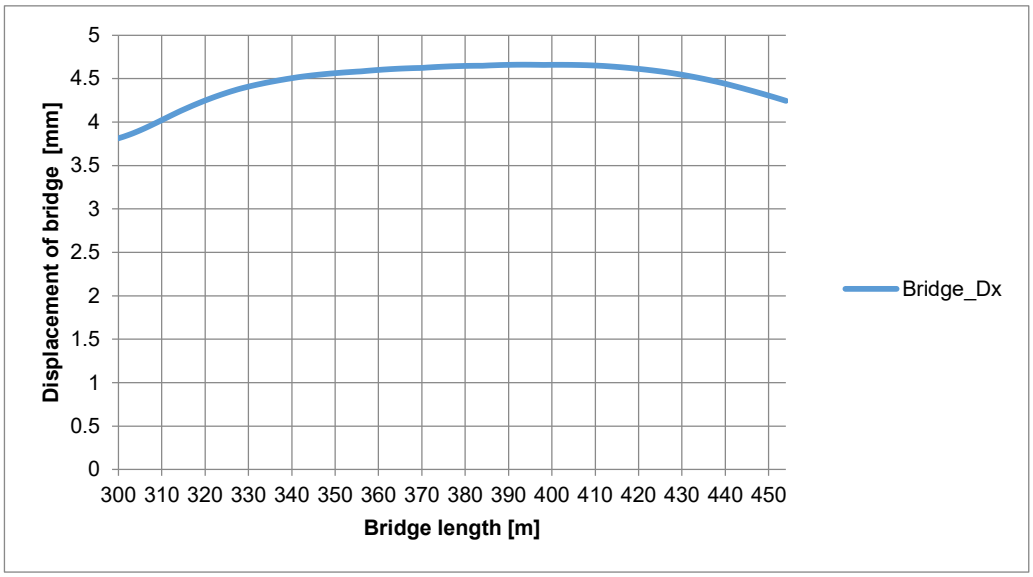
Left track

Maximum tensile stress in rail = **+0,00+60,70+13,60 = +74,30 MPa ≤ +92,00 MPa**

Right track

Maximum tensile stress in rail **= +0,00+58,10+13,60 = +71,70 MPa ≤ +92,00 MPa**

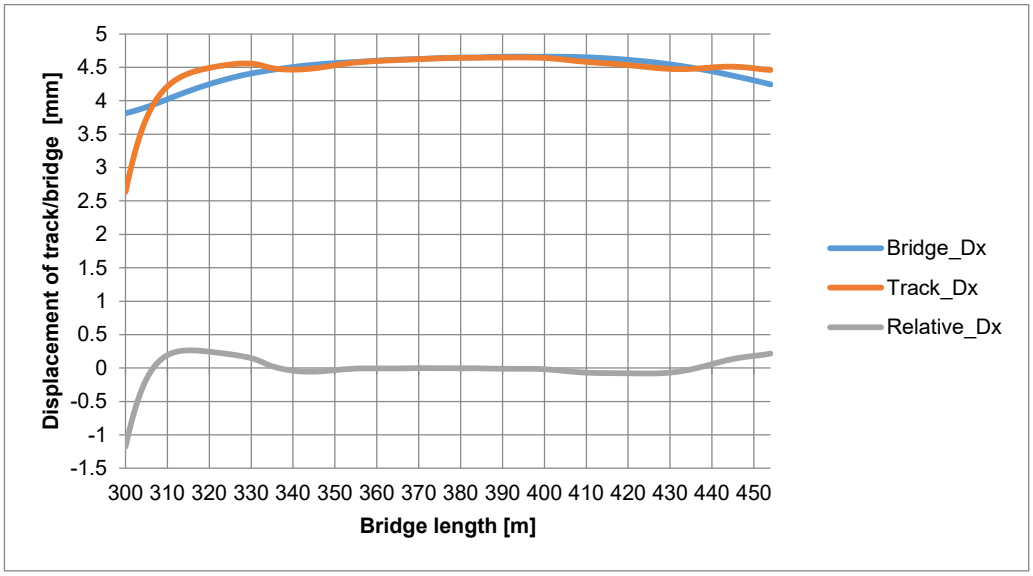
5) Absolute horizontal displacement of bridge superstructure due to acceleration/braking of the train



Maximum absolute horizontal displacement of bridge superstructure due to acceleration/braking of the train = **4,70 mm ≤ 5 mm**

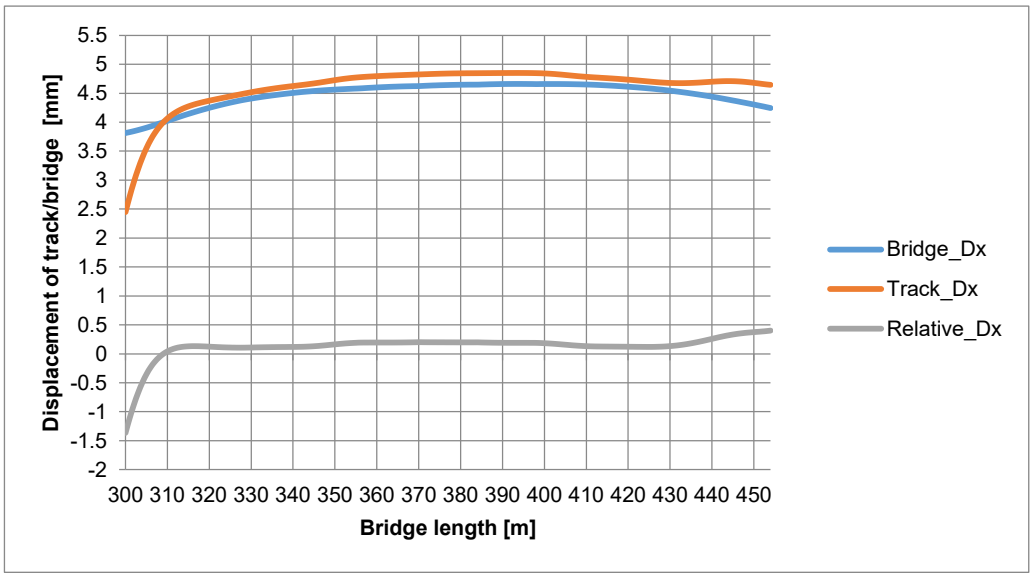
6) Relative horizontal displacement between rail and bridge superstructure due to acceleration/braking of the train

Left track (train acceleration)



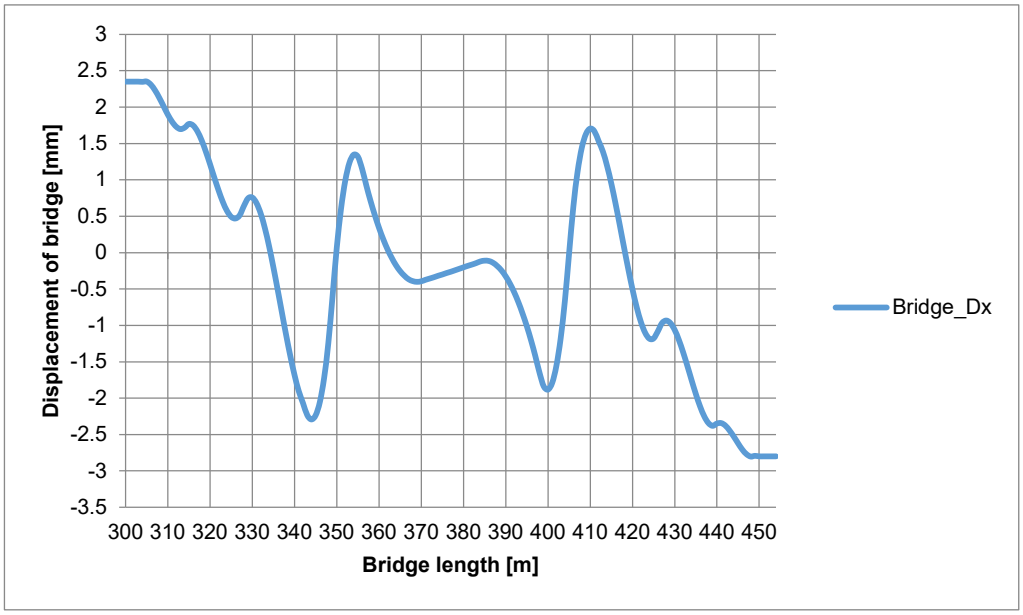
Maximum relative horizontal displacement between rail and bridge superstructure due to acceleration of the train **= <u>1,18 mm ≤ 4 mm</u>**

Right track (train braking)



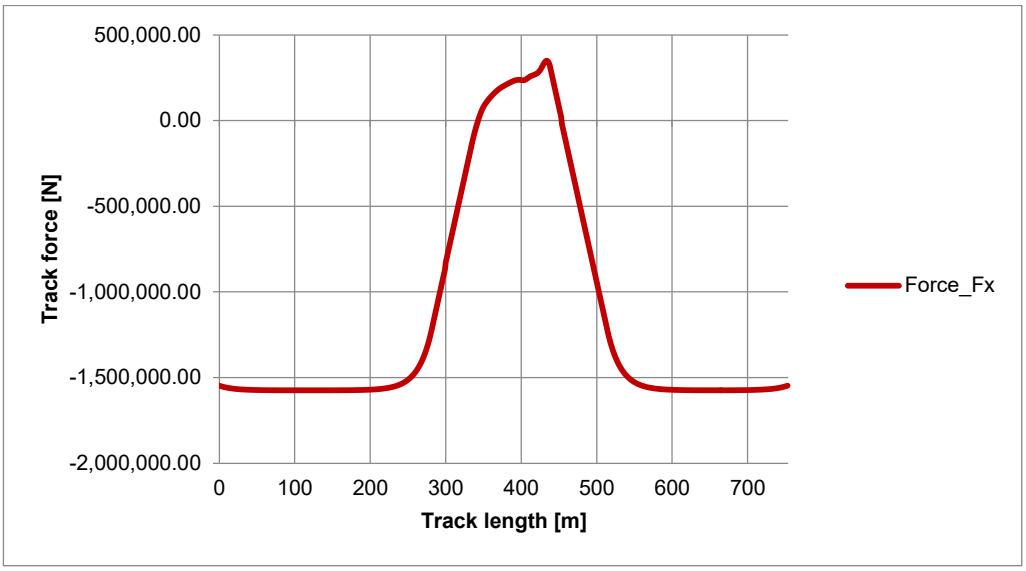
Maximum relative horizontal displacement between rail and bridge superstructure due to braking of the train = **<u>1,37 mm ≤ 4 mm</u>**

7) Horizontal displacement due to rotating of the bridge ends under the vertical load from the train



Maximum horizontal displacement due to rotating of the bridge ends under the vertical load from the train = **2,80 mm < 8 mm**

1.2.1.7 Track stability in the horizontal plane on the bridge in summer climatic conditions

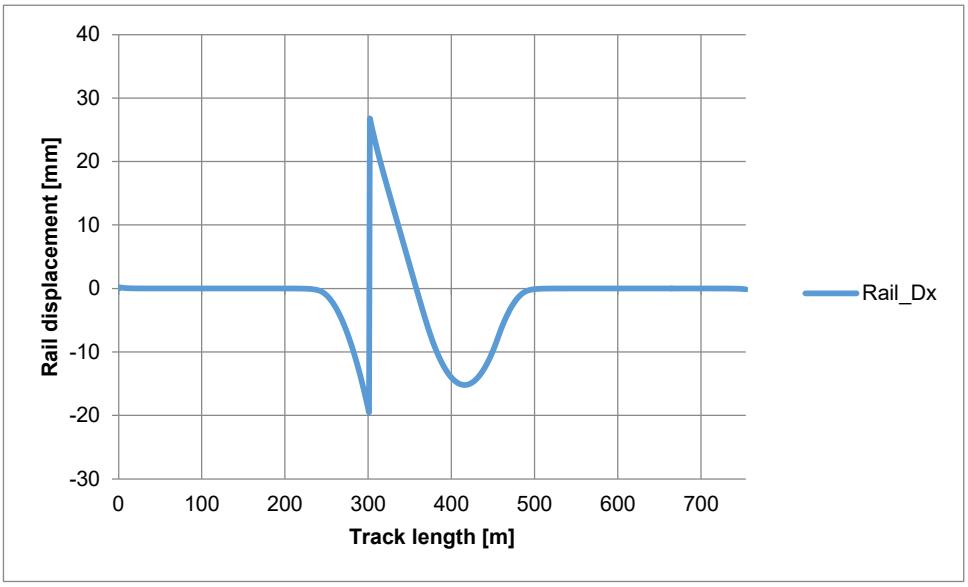


Maximum temperature pressure force in track on the bridge in summer climatic conditions relevant for the calculation of track stability in the horizontal plane = -1574280 N

The input parameters for the calculation of the track stability in the horizontal plane on the bridge in extreme summer climatic conditions are in accordance with Chapters 1.2.1.1, 1.2.1.2 and 1.2.1.3 as well as calculation results of the track/bridge interaction.

Checking the stability of the track in the horizontal plane was carried out for the maximum value of the pressure force in the track -1574280 N, which occurs in the transition zone from the embankment to the bridge due to the built-in rail expansion device in the track on the bridge.

1.2.1.8 Size of the rail gap on the bridge in winter climatic conditions

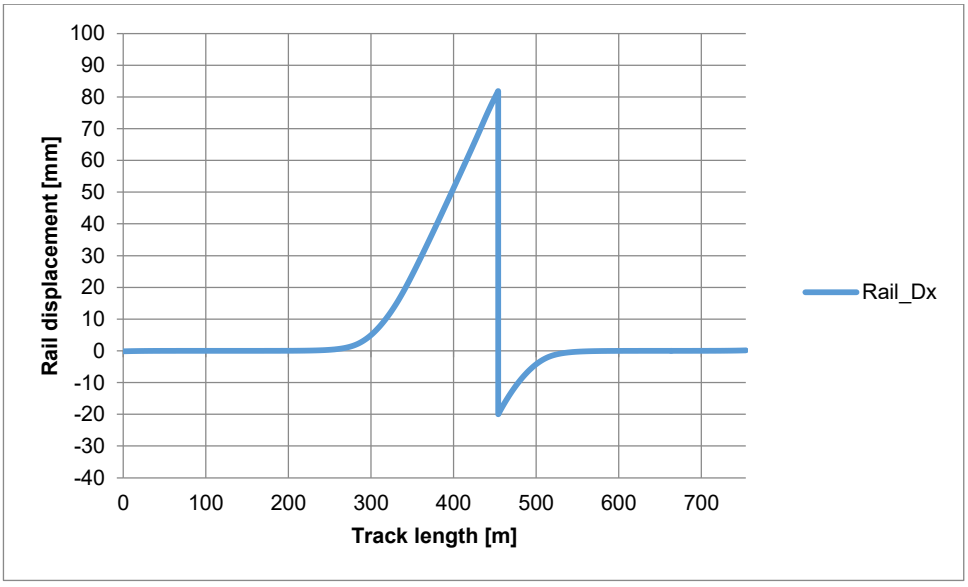


Maximum size of the gap due to cracking of the rail on the bridge in winter climatic conditions in the = **46,32 mm.**

1.2.1.9 Capacity of the rail expansion device in the track on the bridge

The rail expansion device in the track is designed at km 81+721.85 in both tracks.

Summer climatic conditions



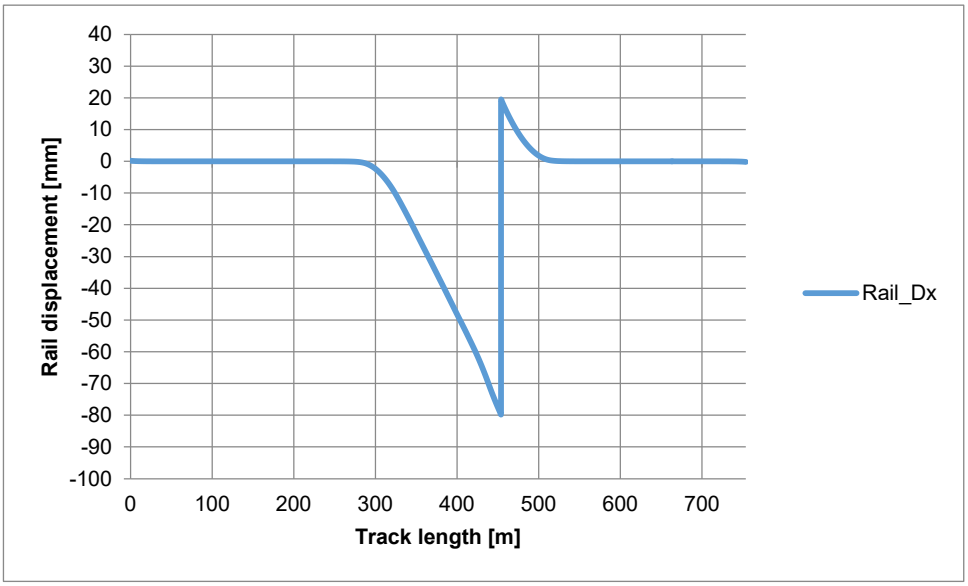
The maximum rail expansion on the bridge in summer climatic conditions **= +81,87 mm**

The maximum rail expansion on the bridge due to braking/acceleration **= +5,94 mm**

The maximum rail expansion on the bridge due to train vertical load **= +2,80 mm**

The total maximum rail expansion on the bridge = 1,5 x (+81,87 + 5,94 + 2,80) **= +135,92 mm**

Winter climatic conditions



The maximum rail contraction on the bridge in winter climatic conditions **= -79,82 mm**

The maximum rail contraction on the bridge due to braking/acceleration **= -4,65 mm**

The total maximum rail contraction on the bridge = 1,5 x (-79,82 - 4,65) **= -126,71 mm**

The installation of rail expansion devices in both tracks with a minimum capacity of **a = ±200 mm** at km 81+721.85 is required. (The capacity of the rail expansion device in the track is harmonized with the calculation of the bridge structure dilatation within the static calculation of the bridge.)

Calculated by:
Zoran Lukovic,dipl.gradj.inz.
licenca broj 310 3032 03

2/2-6.1.6.6.4 CALCULATIONS OF VEHICLE/ TRACK/BRIDGE INTERACTION FOR BRIDGE AT KM 0+751.01 R.T. (0+796,33 L.T.)

CONTENT

1.1 Textual documentation

1.1.1 Technical report

1.1.1.1 Results of the calculation of the track-bridge interaction
1.1.1.2 Results of checking the stability of the track in the horizontal plane on the bridge
1.1.1.3 Results of checking the size of the rail gap on the bridge
1.1.1.4 Technical measures to ensure safety in case of derailment of the vehicle on the bridge

1.2 Numerical documentation

1.2.1 Static calculation

1.2.1.1 Input calculation parameters of the load
1.2.1.2 Input calculation parameters of the track
1.2.1.3 Input calculation parameters of the bridge
1.2.1.4 Calculation model of track-bridge interaction
1.2.1.5 Calculation of track-bridge interaction for summer climatic conditions
1.2.1.6 Calculation of track-bridge interaction for winter climatic conditions
1.2.1.7 Track stability in the horizontal plane on the bridge in summer climatic conditions
1.2.1.8 Size of the rail gap on the bridge in winter climatic conditions
1.2.1.9 Capacity of the rail expansion device in the track on the bridge

1.1 Textual documentation

1.1.1 Technical report

The calculation of the track-bridge interaction for the purpose of arranging the railway superstructure on the bridge at km 0+796,33 was performed in accordance with the requirements of the Technical Specifications of Interoperability for Infrastructure Subsystem (INF TSI).

Input design load parameters are harmonized with: Technical Specifications of Interoperability for Infrastructure Subsystem, as well as Serbian standards SRPS EN 1991-1-5, SRPS EN 1991-1-5/NA, SRPS EN 1991-2, SRPS EN 1991-2/NA.

In this sense, considered the following load due to:

- relevant temperature changes in the axis of the bridge deck and continuously welded rails,
- vertical load of the vehicle in accordance with the load scheme LM 71, SW/0, SW/2.
- horizontal load due to acceleration and/or braking of the vehicle.

All input calculation data in accordance with the bridge structure, railway superstructure, as well as railway vehicles are shown in Chapters 1.2.1.1, 1.2.1.2 and 1.2.1.3. In accordance with design speed of 100 km/h, a static calculation of the track-bridge interaction was performed. The calculation was performed using an integral model of track and bridge structures, with consideration of:

- bridge parameters: bridge disposition (static system, span, expansion length), geometrical characteristics of the bridge superstructure, stiffness and arrangement of bearings,
- track parameters: rail cross-section and rail steel quality, resistance to longitudinal displacement of unloaded and loaded track, taking into account bilinear behavior,
- load parameters: temperature change in the bridge superstructure, temperature changes in the continuously welded rails, acceleration/braking of vehicles, displacement and rotation of the ends of the bridge superstructure due to traffic load.

The connection between the track and the bridge superstructure was modeled using elastic connections with bilinear behavior. The horizontal stiffness of the supporting elements is defined in the model based on UIC 774-3 recommendations and standard SRPS EN 1991-2. In this way, the influences in the rails are obtained, which are relevant for comparison with the allowed additional stresses, proving the stability of the track in the horizontal plane for maximum summer temperatures, as well as gap size due to rail cracking for maximum winter temperatures. The calculation model takes into account the track with continuously welded rails at the length of the bridge and 300 m before and after the bridge, which corresponds to the maximum influential braking length of the vehicle. The layout of the calculation model is shown in Figures 9-11. A detailed description of the model characteristics is presented in Chapter 1.2.1.4.

1.1.1.1 Results of the calculation of the track-bridge interaction

Horizontal reactions on one (of a total of two) fix bridge bearing on the middle pier due to the track-bridge interaction:

Type of load	Summer climatic conditions	Winter climatic conditions
Temperature change in axis of the bridge and continuously welded rails	**-881,80 kN**	**+1179,10 kN**
Acceleration + Braking the train	**±392,05 kN**	**±350,20 kN**
Vertical load from the train	**+156,50 kN**	**+162,25 kN**
Note 1: The positive direction of the reaction corresponds to the direction of growth of the chainage. Note 2: The combined effect of temperature force, acceleration + braking force and the corresponding vertical load from the train is taken to dimensioning the bridge bearings and piers.		

Total horizontal reactions transmitted via shock absorbers (dampers) to the bridge abutments (pier) at km 0+727.33, km 0+837.73 и km 0+865.33 due to the track-bridge interaction:

Type of load	**Summer climatic conditions**	**Winter climatic conditions**
Acceleration + Braking the train		
Abutment km 0+727.33	**±722,40 kN**	**±629,80 kN**
Pier km 0+837.73	**±884,50 kN**	**±816,80 kN**
Abutment km 0+865.33	**±865,10 kN**	**±801,30 kN**
Note 1: The positive direction of the reaction corresponds to the direction of growth of the chainage. Note 2: The acceleration + braking force is taken to dimensioning the bridge piers.		

Maximum additional compressive and tensile stresses in continuously welded rails:

Type of load	**Left track**	**Right track**
Summer climatic conditions		
Temperature change in axis of the bridge and continuously welded rails	0,00 MPa	0,00 MPa
Acceleration /Braking	-45,30 MPa	-40,20 MPa
Vertical load from the train	0,00 MPa	0,00 MPa
Total additional compressive/tensile stresses in the relevant sections of the continuously welded rail	**-45,30 MPa ≤ -72 MPa**	**-40,20 MPa ≤ -72 MPa**
Winter climatic conditions		
Temperature change in axis of the bridge and continuously welded rails	0,00 MPa	0,00 MPa
Acceleration /Braking	+50,50 MPa	+53,10 MPa
Vertical load from the train	+5,70 MPa	+5,70 MPa
Total additional compressive/tensile stresses in the relevant sections of the continuously welded rail	**+56,20 MPa ≤ +92 MPa**	**+58,80 MPa ≤ +92 MPa**
Note 1: Pressure stresses with sign (-), tensile stresses with sign (+)		

Maximum absolute and relative displacements of the track and the bridge superstructure:

Type of displacement	**Summer climatic conditions**	**Winter climatic conditions**
Absolute horizontal displacement of the bridge superstructure due to acceleration/braking of the train	**4,59 mm ≤ 5 mm**	**4,55 mm ≤ 5 mm**
Relative horizontal displacement between the rail and the bridge superstructure due to acceleration/braking of the train	**1,37 mm ≤ 4 mm (braking)** **1,61 mm ≤ 4 mm (acceleration)**	**1,51 mm ≤ 4 mm (acceleration)** **1,34 mm ≤ 4 mm (braking)**
Horizontal displacement due to rotating of the ends of the bridge superstructure under the vertical load from the train	**10,57 mm (at the end of the bridge with the rail expansion device)** **2,00 mm ≤ 8 mm (at the end of the bridge with CWR)**	**10,57 mm (at the end of the bridge with the rail expansion device)** **2,00 mm ≤ 8 mm (at the end of the bridge with CWR)**

1.1.1.2 Results of checking the stability of the track in the horizontal plane on the bridge

Input parameters for checking the stability of the track in the horizontal plane on the bridge at extreme summer temperatures in the rails and the bridge superstructure were adopted in accordance with Chapter 1.2.1.7 and based on the results of the calculation of the track-bridge interaction.

Checking the stability of the track in the horizontal plane was carried out for the maximum value of the pressure force in the track -1574310 N, which occurs in the transition zone from the embankment to the bridge due to the built-in expansion device in the tracks on the bridge.

1.1.1.3 Results of checking the size of the rail gap on the bridge

The calculation was performed under the assumption that the maximum longitudinal resistance during elastic displacement of the rail through the system of elastic rail fastening is 30 kN/m, which corresponds to the force of longitudinal resistance 9 kN.

The calculated value of the rail gap in winter conditions is approximately 49,85 mm.

1.1.1.4 Technical measures to ensure safety in case of derailment of the vehicle on the bridge

- The guard rails, to keep trains on the track in the event of derailment, must be installed, as they can provide safety at speeds up to 160 km/h. The role of the guard rails is to keep the vehicle on track if it derailment on the bridge. In that way, the structure of the bridge is protected from damage and other negative consequences of derailment are reduced (for example. the vehicle fell off the bridge after derailment). Guard rails are mounted on sleepers with a flat upper surface. Guard rails are extended by 10 m to the embankments before and after the bridge and are connected in the middle of the track. Also, is necessary to ensure that the curb upper edge of the concrete bridge deck is 25 cm above the upper edge of the sleeper.

1.2 Numerical documentation

1.2.1 Static calculation

1.2.1.1 Input calculation parameters of the load

Input calculation parameters of load are harmonized with: Technical specifications of interoperability for subsystem of infrastructure, as well as Serbian standards SRPS EN 1991-1-5, SRPS EN 1991-1-5/NA, SRPS EN 1991-2, SRPS EN 1991-2/NA.

Temperature:

- temperature change in continuously welded rails in summer climatic conditions: +42,5 K,
- temperature change in continuously welded rails in winter climatic conditions: -52,5 K,
- temperature change in the bridge superstructure in summer climatic conditions: +49 K,
- temperature change in the bridge superstructure in winter climatic conditions: -44 K.

Vertical load from the train:

- LM71

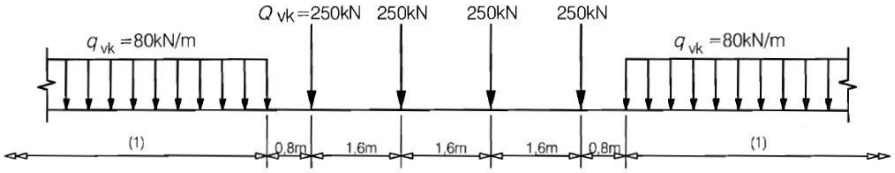
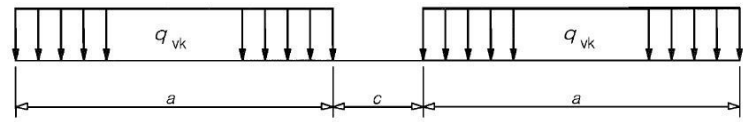


Fig. 2: Load model LM71 (α=1,21)

- SW/0, SW/2



Load Model	q_{vk} [kN/m]	a [m]	c [m]
SW/0	133	15,0	5,3
SW/2	150	25,0	7,0

Fig. 3: Load model SW/0, SW/2 (α=1,21 for SW/0)

Horizontal load from train acceleration/braking LM71, SW/0, SW/2:

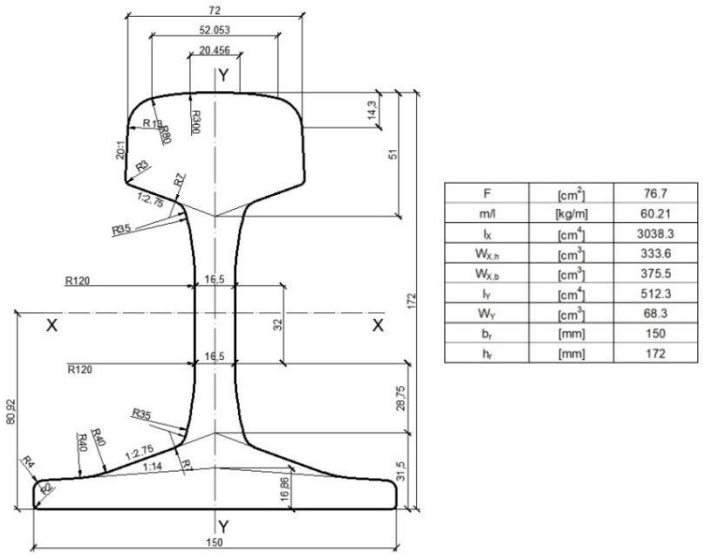
- train acceleration force 33 kN/m (≤1000 kN) for LM71, SW/0, SW/2 (α=1,21 for LM71, SW/0),
- train braking force 20 kN/m (≤6000 kN) for LM71, SW/0 (α=1,21),
- train braking force 35 kN/m for SW/2.

1.2.1.2 Input calculation parameters of the track

The input calculation parameters of the track are harmonized with: Serbian standards SRPS EN 13146-1, SRPS EN 13230 - parts 1 and 2, SRPS EN 13231, SRPS EN 13450, SRPS EN 13481 - parts 1 and 2, SRPS EN 13674-1, SRPS EN 1991-2, Law on the Safety of Railway Transport and Interoperability, as well as the Rulebook on Technical Conditions and Maintenance of the Railway Superstructure.

Rail

- rail cross-section 60E1 (tensile strength of steel 900 N/mm^2) in accordance with SRPS EN 13674-1,
- Young's modulus of elasticity of rail steel E=210 GPa,
- allowable additional tensile stress in rail foot 92 MPa in accordance with SRPS EN 1991-2,
- permissible additional pressure stress in rail 72 MPa in accordance with SRPS EN 1991-2,
- thermal expansion coefficient of rail steel α=1,15x10^{-5} 1/K.



F	[cm^2]	76.7
m/l	[kg/m]	60.21
I_X	[cm^4]	3038.3
$W_{X,h}$	[cm^3]	333.6
$W_{X,b}$	[cm^3]	375.5
I_Y	[cm^4]	512.3
W_Y	[cm^3]	68.3
b_r	[mm]	150
h_r	[mm]	172

Fig. 4: Rail cross-section 60E1 with geometric characteristics

Elastic rail fastening systems

For concrete sleepers in accordance with a series of Serbian standards SRPS EN 13481 - parts 1 and 2 and SRPS EN 13146-1.

- minimum longitudinal resistance to rail displacement ≥ 7 kN (calculated with 9 kN) in accordance with SRPS EN 13674-1.

Mono block prestressed concrete sleepers with a flat top surface

In accordance with a series of Serbian standards SRPS EN 13481-2 and SRPS EN 13230 - parts 1 and 2.

- minimum sleeper mass 281 kg without rail fastening,
- sleeper length 260 cm,
- longitudinal axial distance between sleepers 60 cm,
- minimum active backing surface of sleeper on ballast 0,57 m^2.

Rail expansion device

Rail expansion device is projected at km 0+865.33 in both tracks.

Ballast prism of gravel

In accordance with a series of Serbian standards SRPS EN 13450 with the dimensions of the ballast prism according to SRPS EN 13231.

- the minimum thickness of the ballast prism on the bridge below the lower edge of the sleeper in the cross-section below the rail 35 cm,
- width of the shoulder part of the ballast prism on the concrete deck of the bridge > 50 cm,
- resistance of the ballast prism to the longitudinal displacement of the unloaded track k=20 kN/m in accordance with SRPS EN 1991-2,
- resistance of the ballast prism to the longitudinal displacement of the loaded track k=60 kN/m in accordance with SRPS EN 1991-2.

1.2.1.3 Input calculation parameters of the bridge

The input design parameters of the bridge are defined in accordance with the characteristics of the bridge structure.

- the bridge is a continuous girder static system with spans 27.6 m + 82.8 m + 27.6 m,
- the bridge superstructure consists of a steel truss structure with a coupled concrete deck on the lower chord of the truss,
- steel truss structure is constructed from steel grade S355,
- concrete deck is made of concrete class C35/45,
- the support of bridge superstructure is done over 12 bearings, 4 on each abutment, and 2 on each middle pier,
- shock absorbers (dampers) to accept the impact due to braking/acceleration of the railway vehicle are placed on the bridge abutments (pier) at km 0+727,33, km 0+837,73 и km 0+865,33,

- the required minimum longitudinal (horizontal) stiffness of the supports of bridge superstructure due to acceleration/braking train is ≥ 200000 kN/m,
- the expansion lengths of the bridge are L_{T1}=27.6 m and L_{T2}=110.4 m,
- bridge is straight,
- on the bridge there is a two-track railway designed for speed V_p=100 km/h,
- the maximum permissible longitudinal relative displacement between the continuously welded rail and the bridge superstructure due to acceleration/braking of the train is ≤ 4 mm,
- the maximum permissible longitudinal absolute displacement of the bridge superstructure due to acceleration/braking of the train is ≤ 5 mm,
- the maximum permissible longitudinal displacement of the bridge superstructure due to the rotation of the bridge ends under the vertical load from the train is ≤ 8 mm.

Longitudinal section

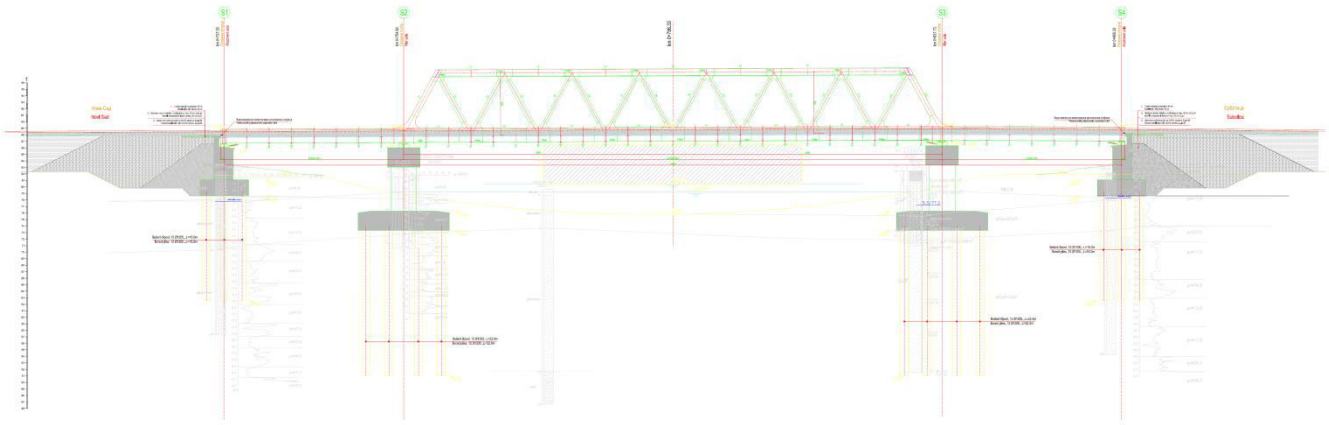


Fig. 5: Longitudinal section of the bridge on km 0+796.33

Cross-section

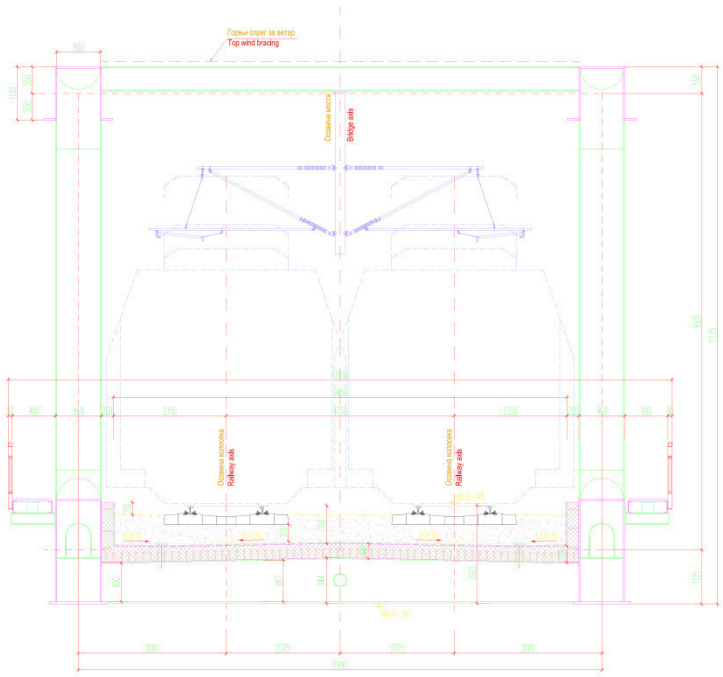


Fig. 6: Cross-section of the bridge on km 0+796.33

Bearing scheme

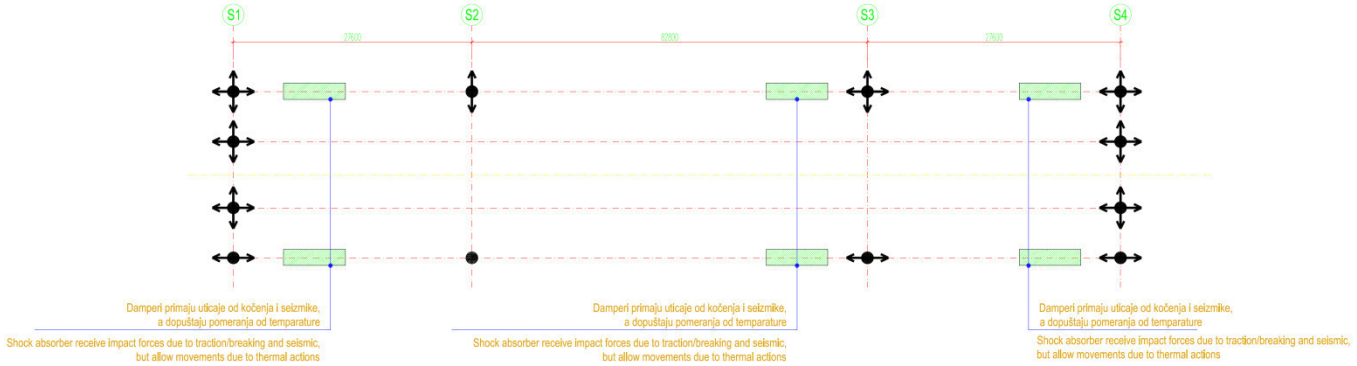
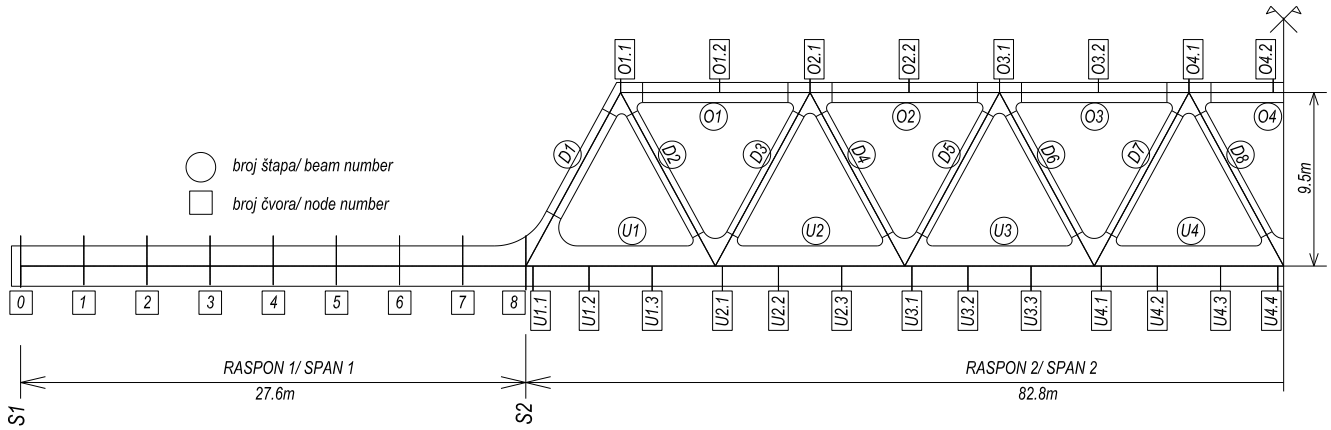

S1
S2
S3
S4
Damperi primaju uticaje od kočenja i seizmike, a dopuštaju pomeranja od temparature
Shock absorber receive impact forces due to traction/breaking and seismic, but allow movements due to thermal actions

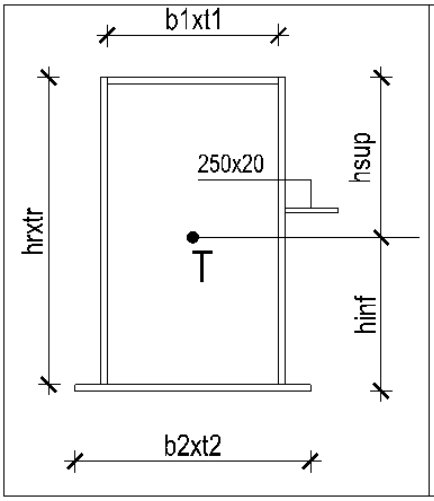
Fig. 7: Bearing scheme of bridge on km 0+796.33

Geometrical characteristics of elements bridge superstructure

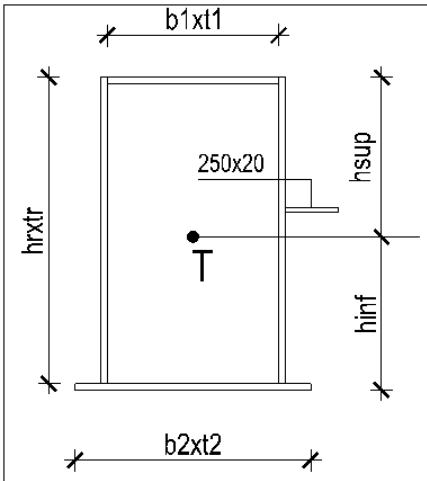
Steel truss structure with coupling concrete deck:



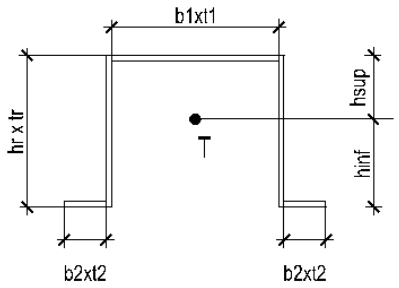
- Elements of steel truss structure [mm]



	Штап 0-6	Штап 6-7	Штап 7-8
b1 (mm)	900	900	900
t1 (mm)	25	40	50
b2 (mm)	1100	1100	1100
t2 (mm)	20	35	50
hr (mm)	217.5	219	220
tr (mm)	20	25	40
hsup (mm)	-1108	-1132	-1170
hinf (mm)	1087	1093	1080
A(cm2)	1385	1925	2860
Iy (cm4)	8925739	13708879	19768920
Wysup (cm3)	-80528	-121060	-169008
Wyinf (cm3)	82144	125470	182995
Iz (cm4)	2454311	3267773	5102347
Wz (cm3)	40905	85039	85039



	Доњи појас U1.1, U8.3	Доњи појас U1.2, U8.2	Доњи појас U1.3, U8.1, U2- U7
b1 (mm)	900	900	900
t1 (mm)	50	40	25
b2 (mm)	1100	1100	1100
t2 (mm)	50	35	20
hr (mm)	220	219	217.5
tr (mm)	40	25	20
hsup (mm)	-1170	-1132	-1108
hinf (mm)	1080	1093	1087
A(cm2)	2860	1925	1385
Iy (cm4)	19768920	13708879	8925739
Wysup (cm3)	-169008	-121060	-80528
Wyinf (cm3)	182995	125470	82144
Iz (cm4)	5102347	3267773	2454311
Wz (cm3)	85039	85039	40905

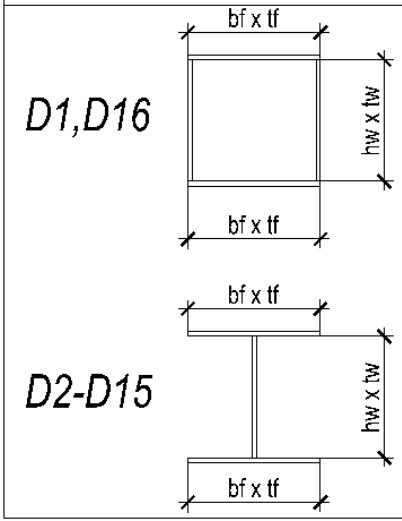


	Горњи појас O1,O7	Горњи појас O2,O6	Горњи појас O3 - O5
b1 (mm)	900	900	900
t1 (mm)	20	30	40
b2 (mm)	250	240	300
t2 (mm)	25	30	40
hr (mm)	1100	1100	1100
tr (mm)	15	25	30
hsup (mm)	-503	-480	-500
hinf (mm)	597	620	600
A(cm2)	635	964	1260
iy(cm)	43.6	41.9	43.0
iz(cm)	44.4	44.1	45.8
Iy (cm4)	1204703	1692727	2327464
Iz (cm4)	1253908	1875729	2641140
$W_{y,sup}$ *(cm3)*	-23590	-35265	-46549
$W_{y,inf}$ *(cm3)*	20179	27302	38791
W_z *(cm3)*	17537	26234	36939

Дијагонале карактеристике бруто пресека

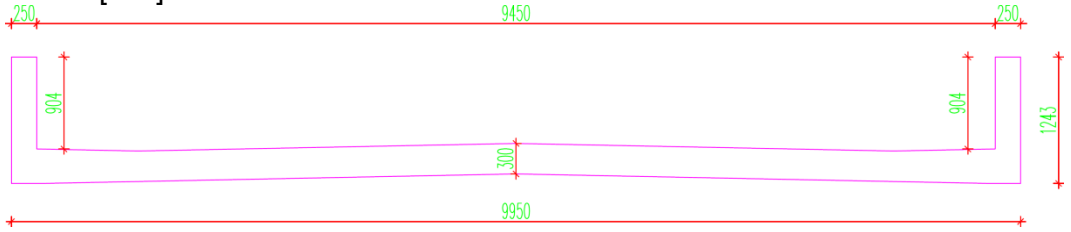
D1,D16

D2-D15



	D1,D16	D2 – D4 D13 - D15	D5 - D12
b_f*(mm)*	900	700	600
t_f*(mm)*	40	30	25
h_w*(mm)*	900	900	900
t_w*(mm)*	20	20	15
A(cm2)	1048	600	435
Iy (cm4)	1516029	1029960	733000
W_y *(cm3)*	30939	21458	15596
iy (cm)	32.7	41.4	41.0
Iz (cm4)	1121117	171560	90025
W_z *(cm3)*	24914	4902	3001
iz (cm)	38.0	16.9	14.4

- Concrete deck [mm]



Material characteristics of the elements bridge superstructure

All elements of the steel truss structure are made of steel grade S355 with the following characteristics:

Steel grade S355:

- $E=2,1x10^{8}$ kN/m^2
- v=0,3
- $\alpha=1,2x10^{-5}$ 1/C
- $\rho=76,98$ kN/m^3

Concrete deck is made of concrete class C35/45 with the following characteristics:

Concrete class C35/45:

- $E= 3,4077x10^{7}$ kN/m^2 ($Er=9,33x10^{6}$ kN/m^2 - reduced value of cracked concrete with reinforcement)
- v=0,2
- $\alpha=1,0x10^{-5}$ 1/C
- $\rho=25,00$ kN/m^3

Steel reinforcement in the concrete is grade B500B:

Steel reinforcement grade B500B:

- $E=2,1x10^{8}$ kN/m^2
- v=0,3
- $\alpha=1,2x10^{-5}$ 1/C
- $\rho=76,98$ kN/m^3

1.2.1.4 Calculation model of track-bridge interaction

Based on the calculation of the track-bridge interaction, the influences are obtained in the following form:

- longitudinal forces in supports (reactions of fixed supports),
- additional stresses in rails,
- absolute and relative displacements of the rails and the bridge superstructure.

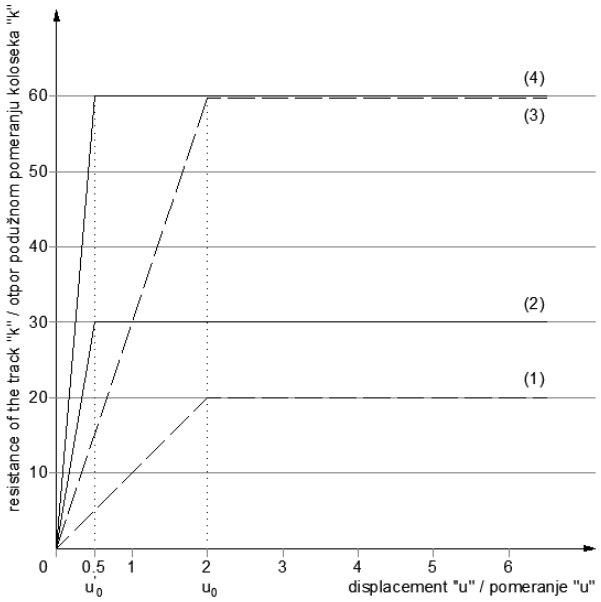
Influences due to interaction are determined iteratively, by a series of nonlinear simulations, in order to determine the behavior of the track-bridge system, due to temperature changes in the bridge superstructure, vertical load from the train and longitudinal forces due to train acceleration/braking.

The calculation of the track-bridge interaction is carried out using an integral model of track and bridge structure taking into account:

- bridge parameters: bridge disposition (static system, spans, expansion lengths), geometrical characteristics of the bridge superstructure, stiffness of structure and arrangement of supports,
- track parameters: rail cross-section and rail steel quality, resistance to longitudinal displacement of loaded and unloaded track, taking into account the bilinear behavior of the track-bridge connection,
- load parameters: temperature changes in the bridge superstructure and rails, acceleration and braking of the train, displacement and rotating the ends of the bridge super structure due to traffic load.

The connection between the track elements and the bridge superstructure elements was modeled by means of elastic connections with bilinear behavior in accordance with the Serbian standard SRPS EN 1991-2 (Figure 8).

The model adopts the horizontal stiffness of the fixed support, which corresponds to the real displacement of the bridge superstructure due to acceleration/braking the train. In this way, the influences in the rails are obtained, which are relevant for the analysis of the allowed additional stresses and track stability in the horizontal plane at maximum summer temperature, as well as the size of the gap when the rail cracks at maximum winter temperature. The calculation model takes into account the track with continuously welded rails at a length of 300 m in before and after the bridge, which corresponds to the maximum influential length of train braking.



(1) - resistance of sleeper in ballast (unloaded track)
otpor podužnom pomeranju praga kroz zastor (neopterećen kolosek)

(2) - resistance of rail in sleeper (unloaded track) (frozen ballast or track without ballast)
otpor podužnom pomeranju šine u odnosu na prag (neopterećen kolosek) (smrznuti zastor ili kolosek na čvrstoj podlozi)

(3) - resistance of sleeper in ballast (loaded track)
otpor podužnom pomeranju praga kroz zastor (opterećen kolosek)

(4) - resistance of rail in sleeper (loaded track) (frozen ballast or track without ballast)
otpor podužnom pomeranju šine u odnosu na prag (opterećen kolosek) (smrznuti zastor ili kolosek na čvrstoj podlozi)

u'_0 - ultimate relative displacement of the rail to the sleeper
granično relativno pomeranje šine u odnosu na prag

u_0 - ultimative relative displacement of the sleeper in the ballast
granično relativno pomeranje praga u odnosu na zastor

Note: / Napomena:
rail profile 60E1, concrete sleepers B70 at a distance of 60 cm and longitudinal resistance of the rail in the track 2x9 kN, minimum thickness of the compacted ballast below the sleeper is 30 cm.
šine 60E1, betonski pragovi B70 na razmaku 60 cm i podužni otpor šina u koloseku 2x9 kN, minimalna debljina zbijenog zastora ispod praga 30 cm.

Fig. 8: Longitudinal displacement resistance of track/rail

View of calculation model

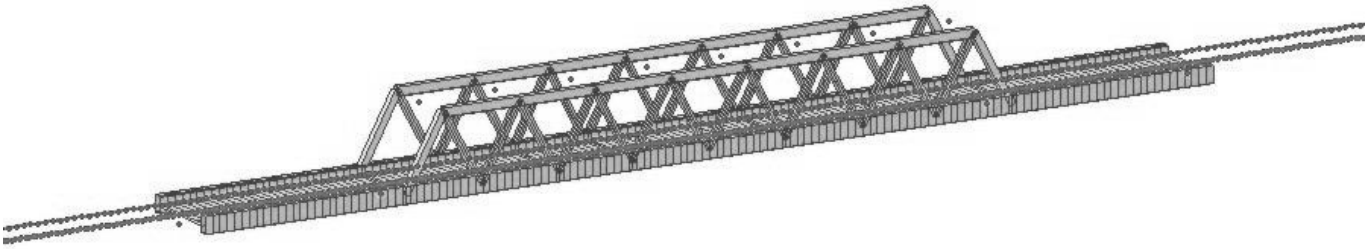


Fig. 9: View of calculation model

Longitudinal section of the calculation model

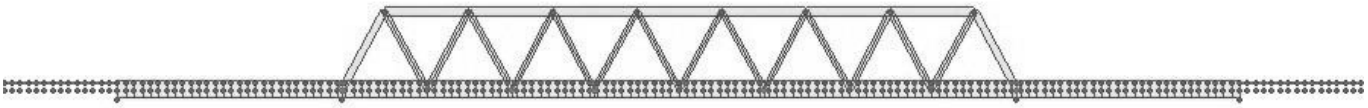


Fig. 10: Longitudinal section of the calculation model

Cross-section of calculation model

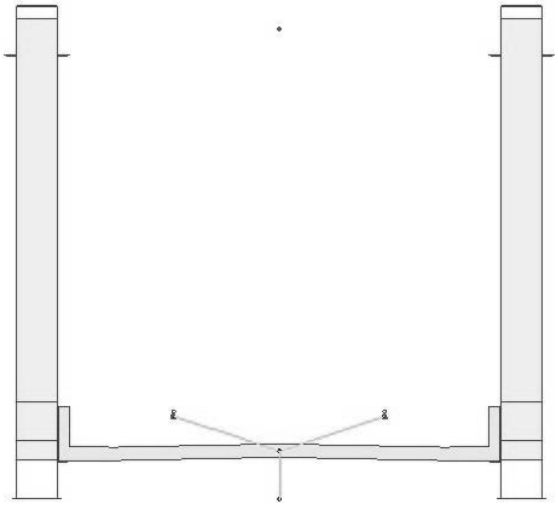
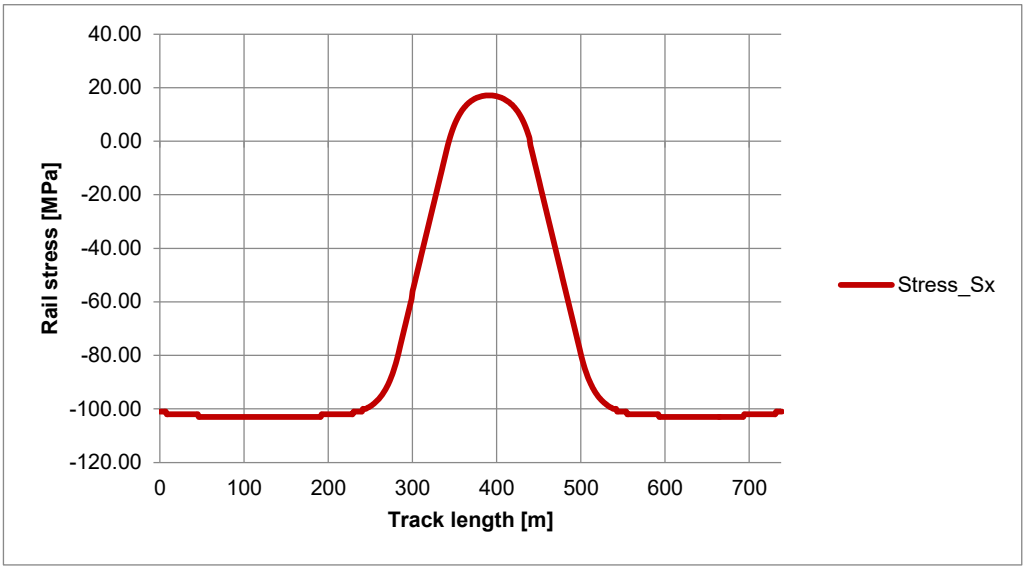


Fig. 11: Cross-section of the calculation model with elastic connections with bilinear behavior between the track and the bridge superstructure

1.2.1.5 Calculation of track-bridge interaction for summer climatic conditions

1) Rail stress due to temperature change in bridge superstructure and continuously welded rails

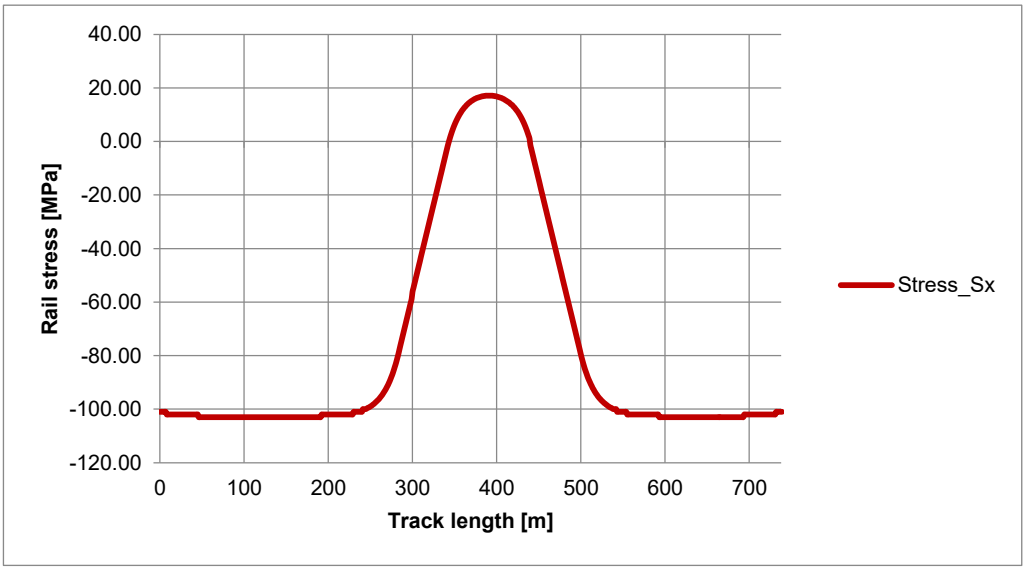
Left track



Maximum pressure stress in rail = **-58,80 MPa (the additional pressure stress is equal to zero)**

Maximum tensile stress in rail = **0,00 MPa**

Right track

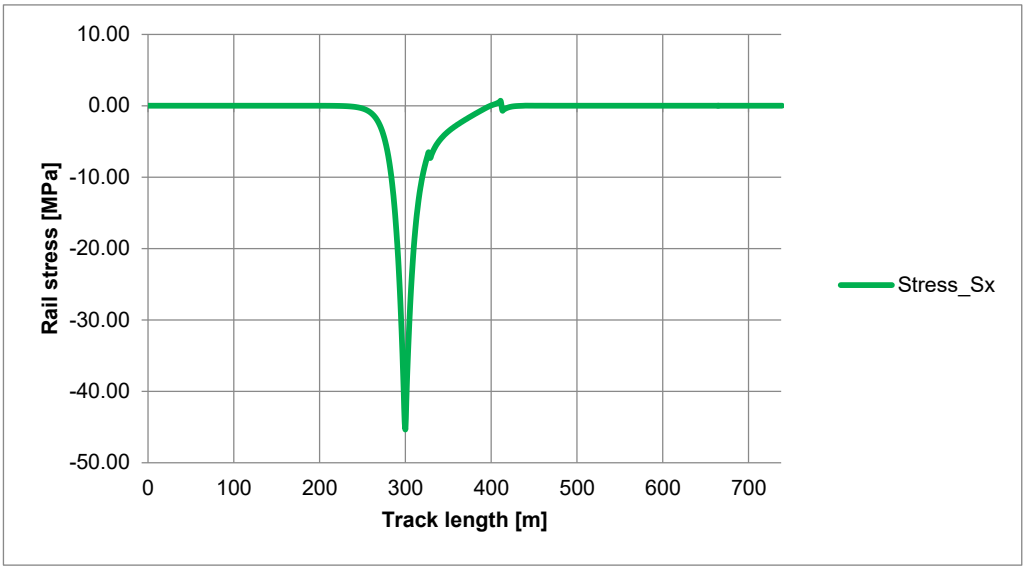


Maximum pressure stress in rail = **-58,80 MPa (the additional pressure stress is equal to zero)**

Maximum tensile stress in rail = **0,00 MPa**

2) Rail stress due to train acceleration/braking

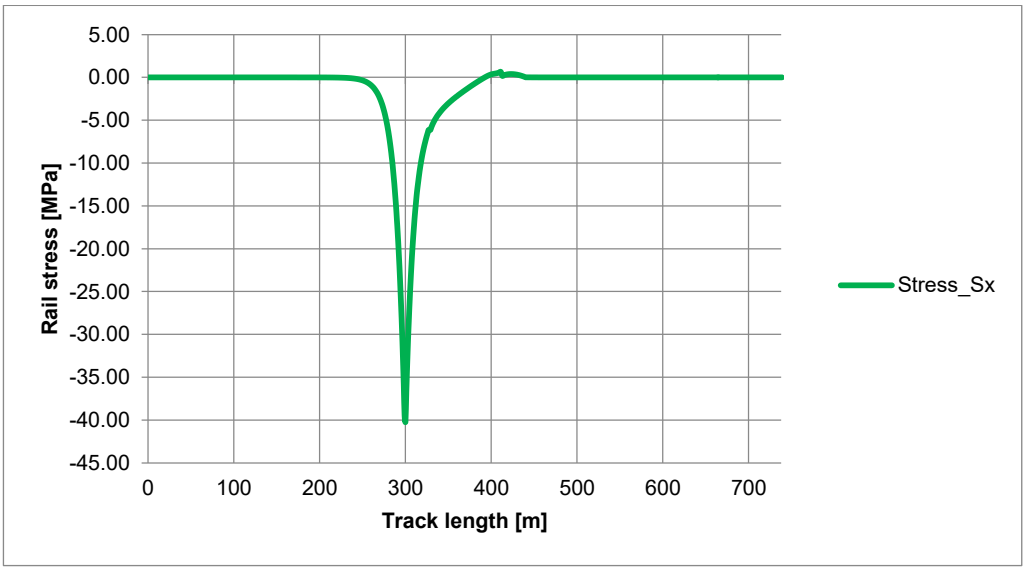
Left track (train braking)



Maximum pressure stress in rail = **-45,30 MPa**

Maximum tensile stress in rail = **0,00 MPa**

Right track (train acceleration)

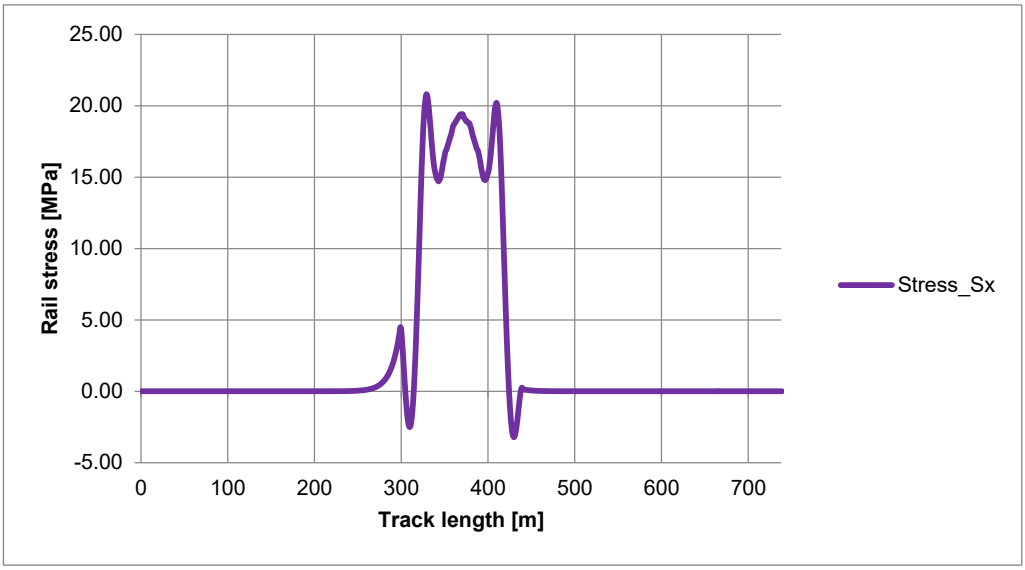


Maximum pressure stress in rail = **-40,20 MPa**

Maximum tensile stress in rail = **0,00 MPa**

3) Rail stress due to vertical bending under train

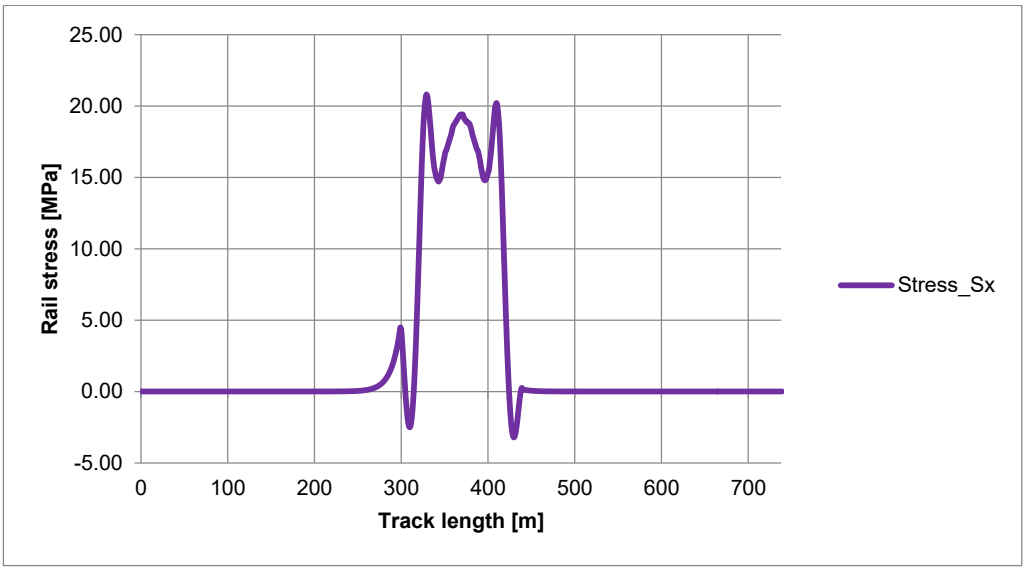
Left track



Maximum pressure stress in rail = **0,00 MPa**

Maximum tensile stress in rail = **+4,49 MPa**

Right track



Maximum pressure stress in rail = **0,00 MPa**

Maximum tensile stress in rail = **+4,49 MPa**

4) Rail stress due to temperature change in bridge superstructure, train acceleration/braking and vertical bending under train

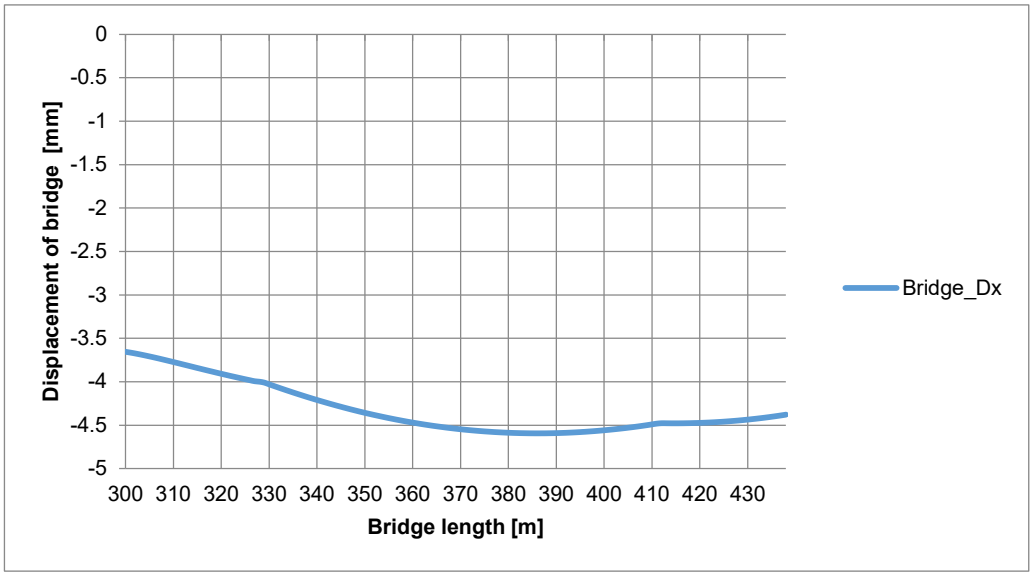
Left track

Maximum pressure stress in rail = **-0,00-45,30-0,00 = -45,30 MPa ≤ -72,00 MPa**

Right track

Maximum pressure stress in rail = **-0,00-40,20-0,00 = -40,20 MPa ≤ -72,00 MPa**

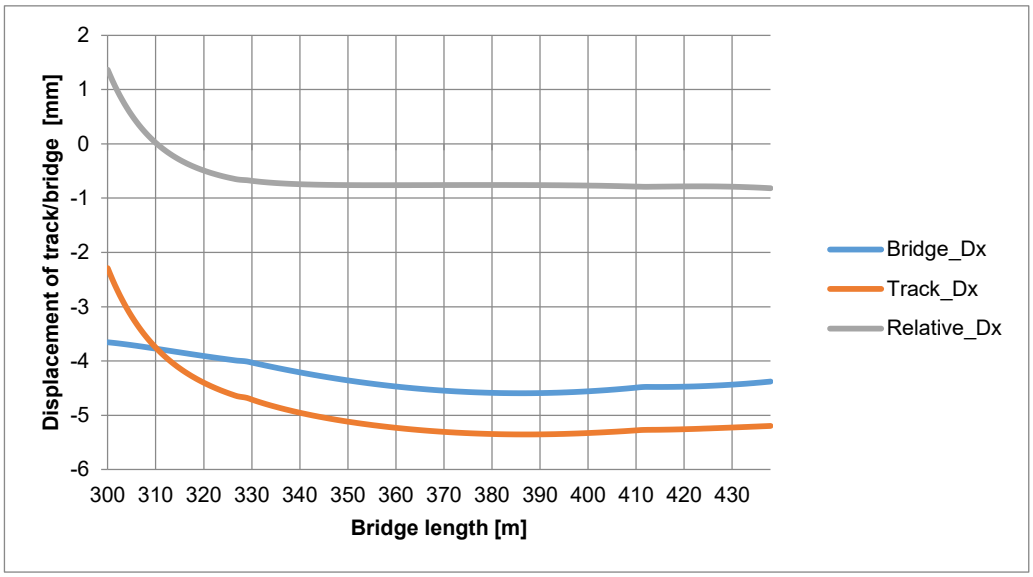
5) Absolute horizontal displacement of bridge superstructure due to acceleration/braking of the train



Maximum absolute horizontal displacement of bridge superstructure due to acceleration/braking of the train = **4,59 mm ≤ 5 mm**

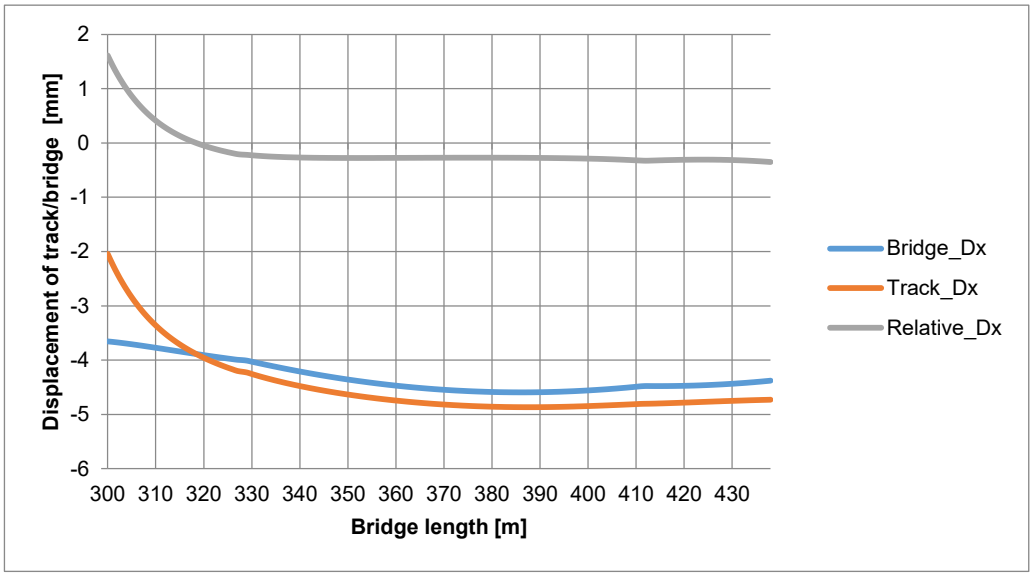
6) Relative horizontal displacement between rail and bridge superstructure due to acceleration/braking of the train

Left track (train braking)



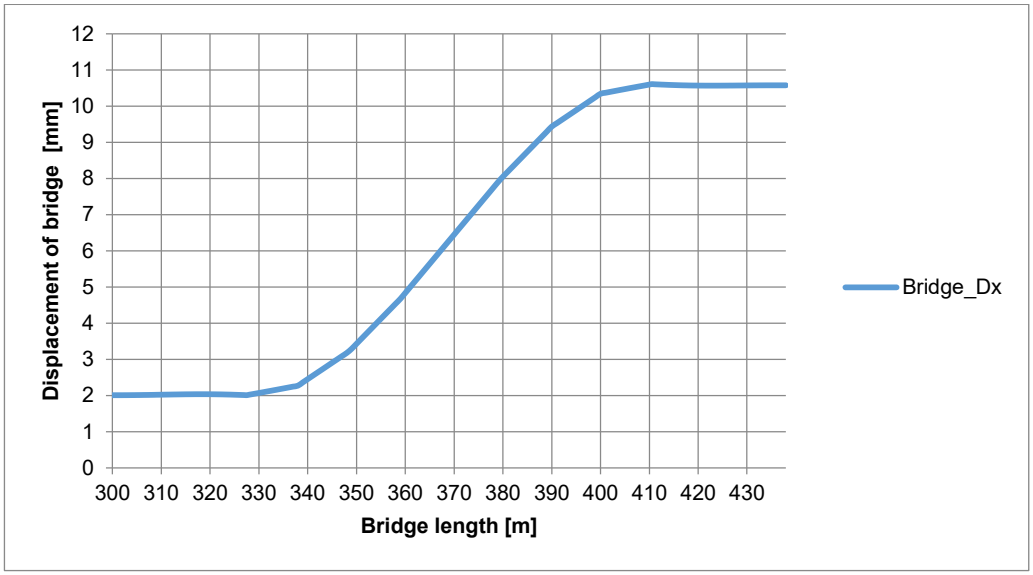
Maximum relative horizontal displacement between rail and bridge superstructure due to braking of the train = **1,37 mm ≤ 4 mm**

Right track (train acceleration)



Maximum relative horizontal displacement between rail and bridge superstructure due to acceleration of the train = **1,61 mm ≤ 4 mm**

7) Longitudinal displacement of bridge superstructure due to rotating of bridge ends under the vertical train load

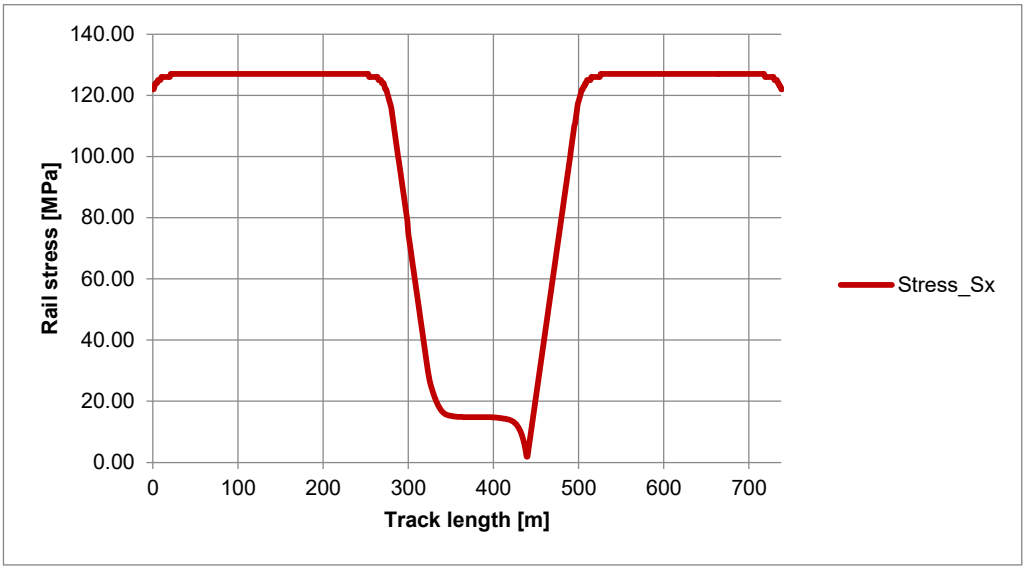


Maximum longitudinal displacement of bridge superstructure due to rotating of bridge ends under the vertical train load is **10.57 mm** at the end of the bridge where the installation of rail expansion devices in both tracks is planned and where in accordance with UIC 774-3 and SRPS EN 1991-2 an exceed of 8 mm is allowed. At the other end of the bridge where the rails are continuously welded, the maximum longitudinal displacement of bridge superstructure due to rotating of bridge ends under the vertical train load is **2.00 mm ≤ 8 mm.**

1.2.1.6 Calculation of track-bridge interaction for winter climatic conditions

1) Rail stress due to temperature change in bridge superstructure and continuously welded rails

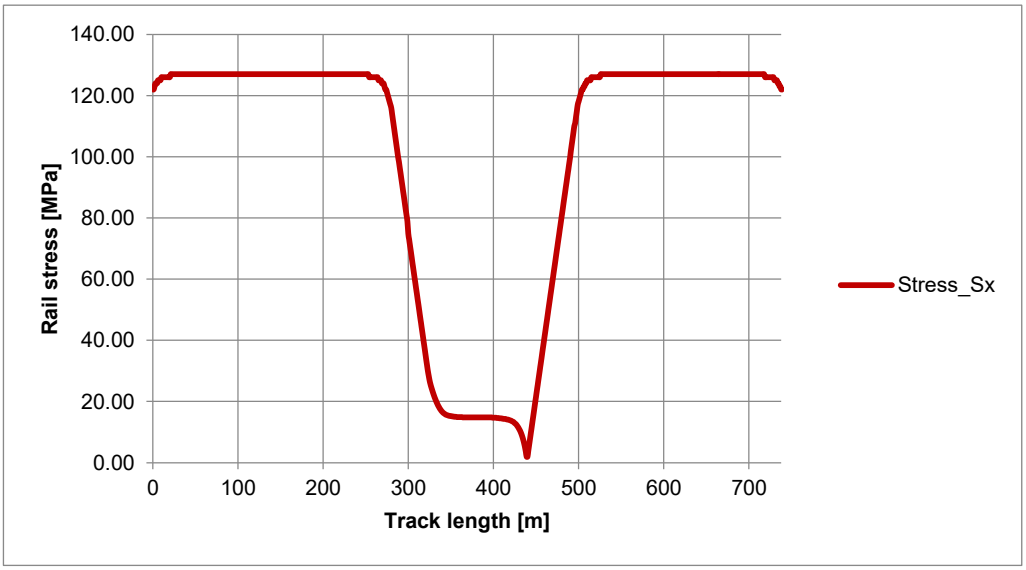
Left track



Maximum pressure stress in rail = **0,00 MPa**

Maximum tensile stress in rail = **+78,80 MPa (the additional tensile stress is equal to zero)**

Right track

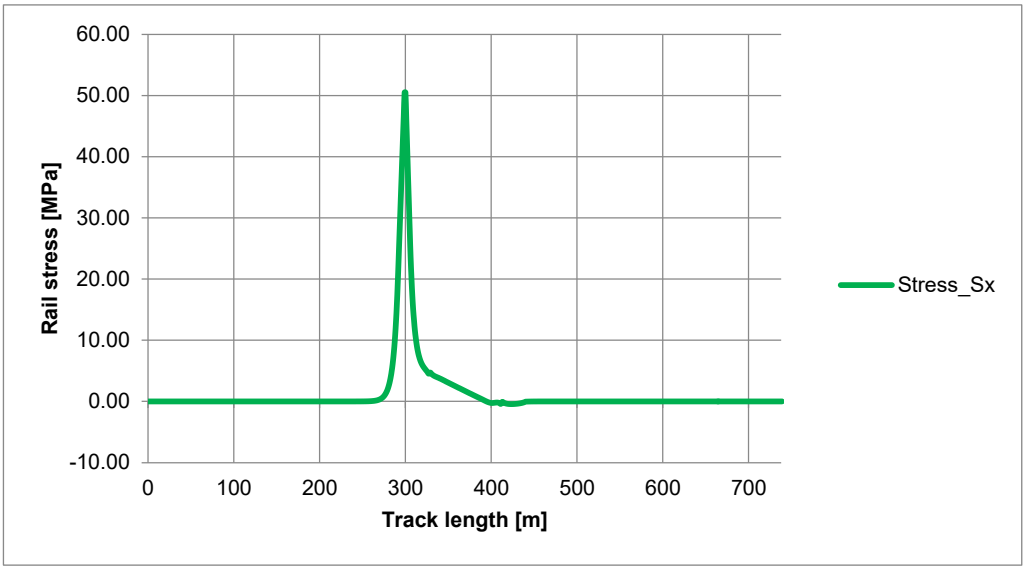


Maximum pressure stress in rail = **0,00 MPa**

Maximum tensile stress in rail = **+78,80 MPa (the additional tensile stress is equal to zero)**

2) Rail stress due to train acceleration/braking

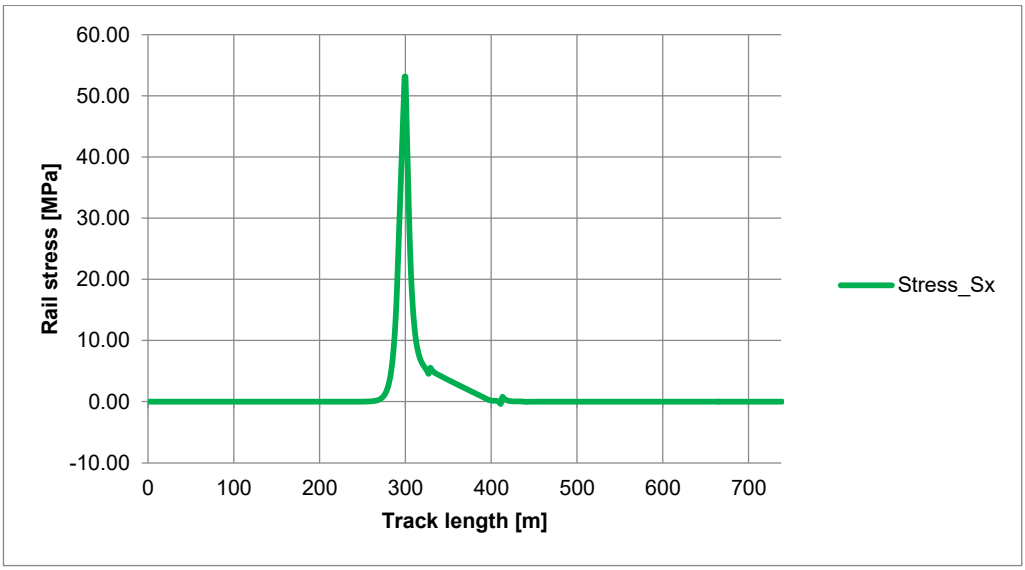
Left track (train acceleration)



Maximum pressure stress in rail = **0,00 MPa**

Maximum tensile stress in rail = **+50,50 MPa**

Right track (train braking)

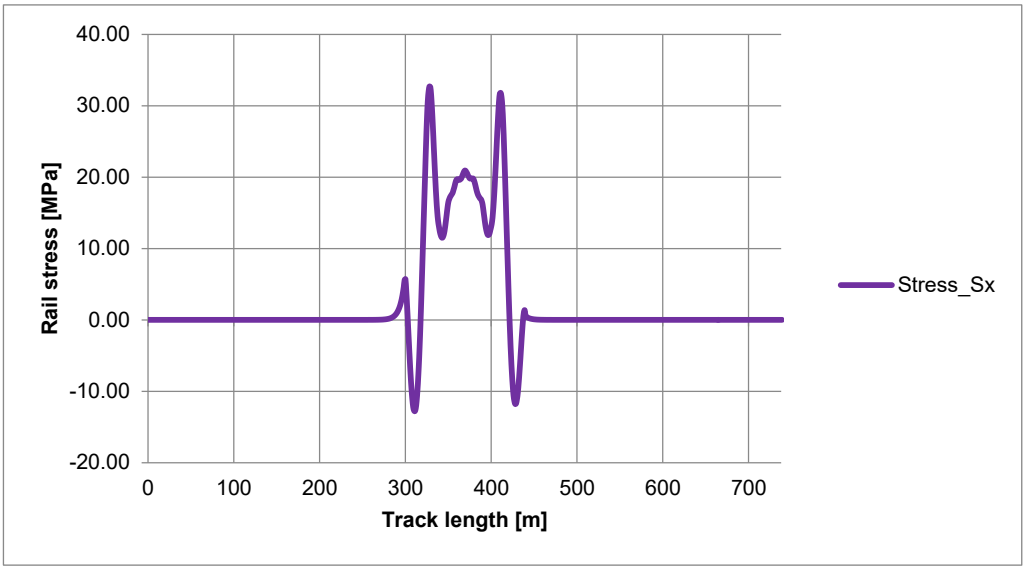


Maximum pressure stress in rail = **0,00 MPa**

Maximum tensile stress in rail = **+53,10 MPa**

3) Rail stress due to vertical bending under train

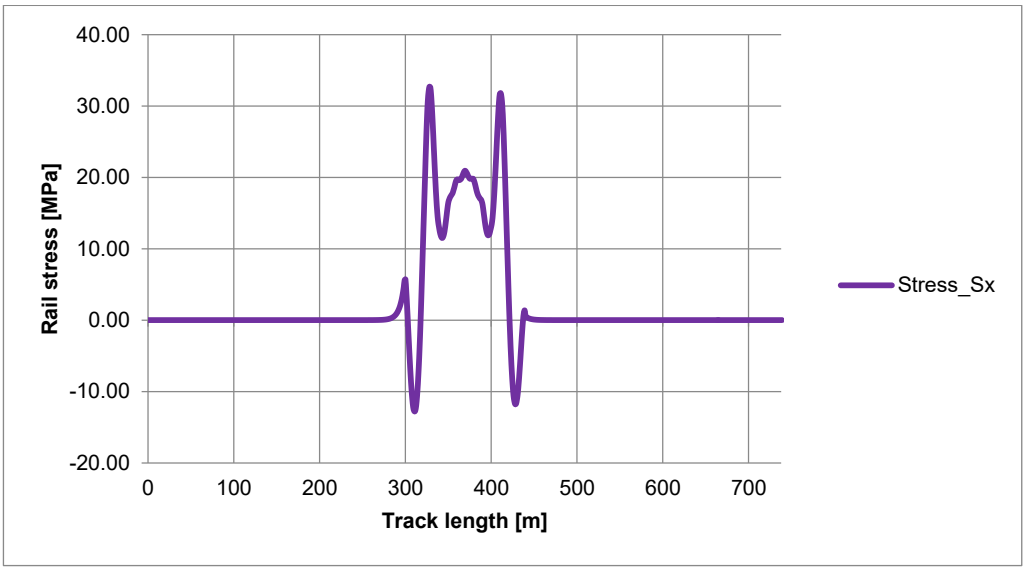
Left track



Maximum pressure stress in rail = **0,00 MPa**

Maximum tensile stress in rail = **+5,70 MPa**

Right track



Maximum pressure stress in rail = **0,00 MPa**

Maximum tensile stress in rail = **+5,70 MPa**

4) Rail stress due to temperature change in bridge superstructure, train acceleration/braking and vertical bending under train

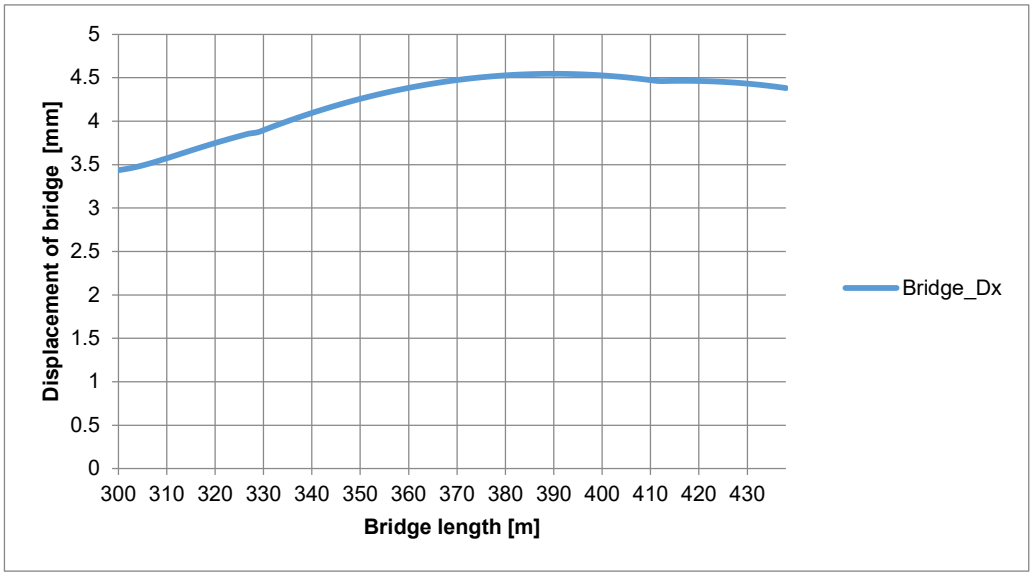
Left track

Maximum tensile stress in rail = **+0,00+50,50+5,70 = +56,20 MPa ≤ +92,00 MPa**

Right track

Maximum tensile stress in rail **= +0,00+53,10+5,70 = +58,80 MPa ≤ +92,00 MPa**

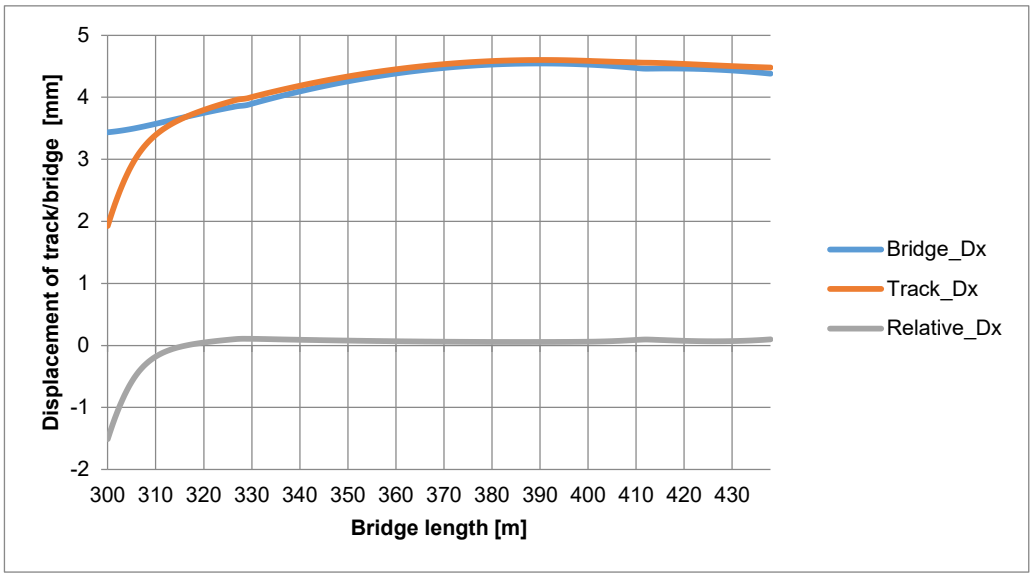
5) Absolute horizontal displacement of bridge superstructure due to acceleration/braking of the train



Maximum absolute horizontal displacement of bridge superstructure due to acceleration/braking of the train = **4,55 mm ≤ 5 mm**

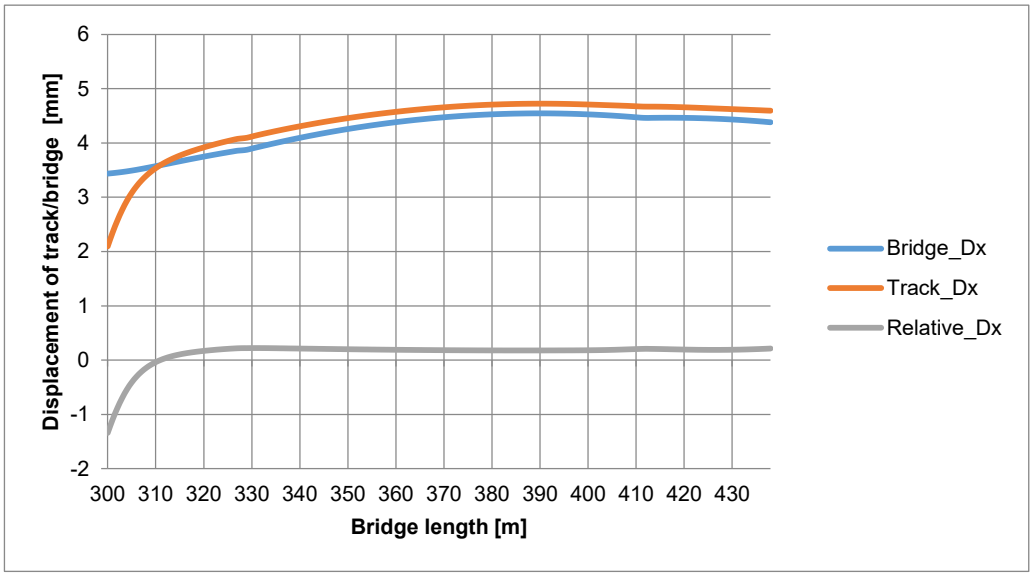
6) Relative horizontal displacement between rail and bridge superstructure due to acceleration/braking of the train

Left track (train acceleration)



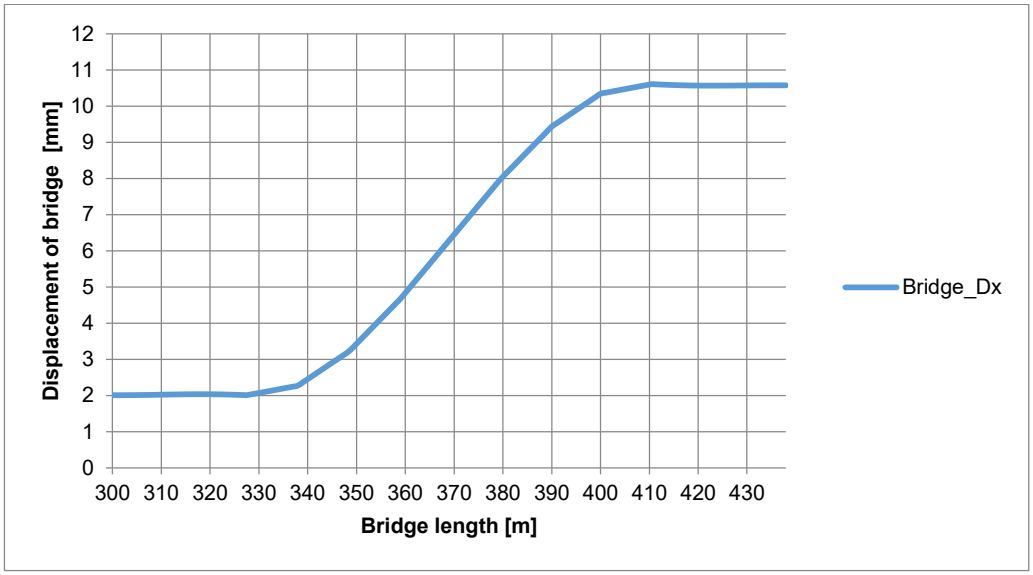
Maximum relative horizontal displacement between rail and bridge superstructure due to acceleration of the train **= 1,51 mm ≤ 4 mm**

Right track (train braking)



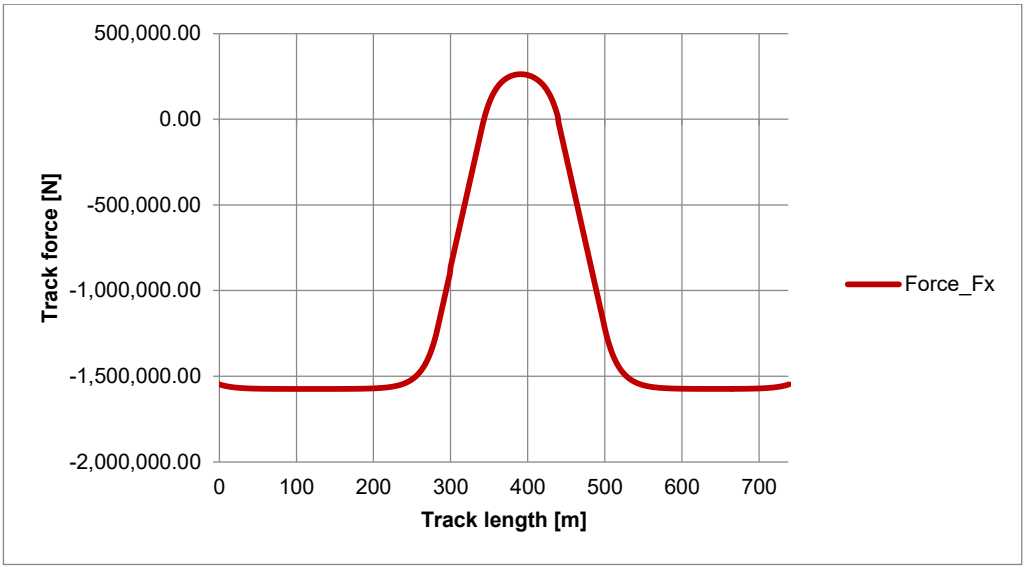
Maximum relative horizontal displacement between rail and bridge superstructure due to braking of the train = **1,34 mm ≤ 4 mm**

7) Longitudinal displacement of bridge superstructure due to rotating of bridge ends under the vertical train load



Maximum longitudinal displacement of bridge superstructure due to rotating of bridge ends under the vertical train load is **10.57 mm** at the end of the bridge where the installation of rail expansion devices in both tracks is planned and where in accordance with UIC 774-3 and SRPS EN 1991-2 an exceed of 8 mm is allowed. At the other end of the bridge where the rails are continuously welded, the maximum longitudinal displacement of bridge superstructure due to rotating of bridge ends under the vertical train load is **2.00 mm ≤ 8 mm.**

1.2.1.7 Track stability in the horizontal plane on the bridge in summer climatic conditions

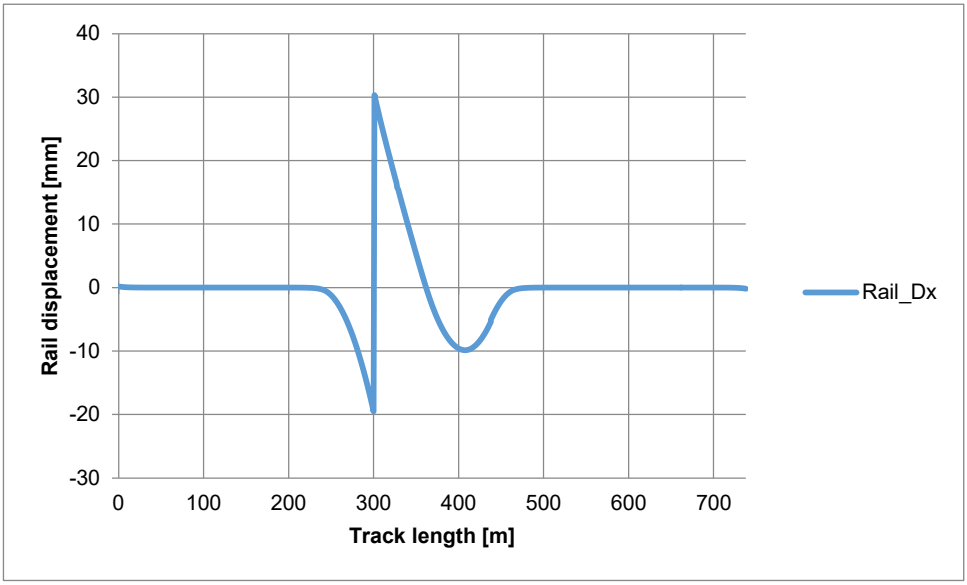


Maximum temperature pressure force in track on the bridge in summer climatic conditions relevant for the calculation of track stability in the horizontal plane = -1574310 N

The input parameters for the calculation of the track stability in the horizontal plane on the bridge in extreme summer climatic conditions are in accordance with Chapters 1.2.1.1, 1.2.1.2 and 1.2.1.3 as well as calculation results of the track/bridge interaction.

Checking the stability of the track in the horizontal plane was carried out for the maximum value of the pressure force in the track -1574310 N, which occurs in the transition zone from the embankment to the bridge due to the built-in rail expansion device in the track on the bridge.

1.2.1.8 Size of the rail gap on the bridge in winter climatic conditions

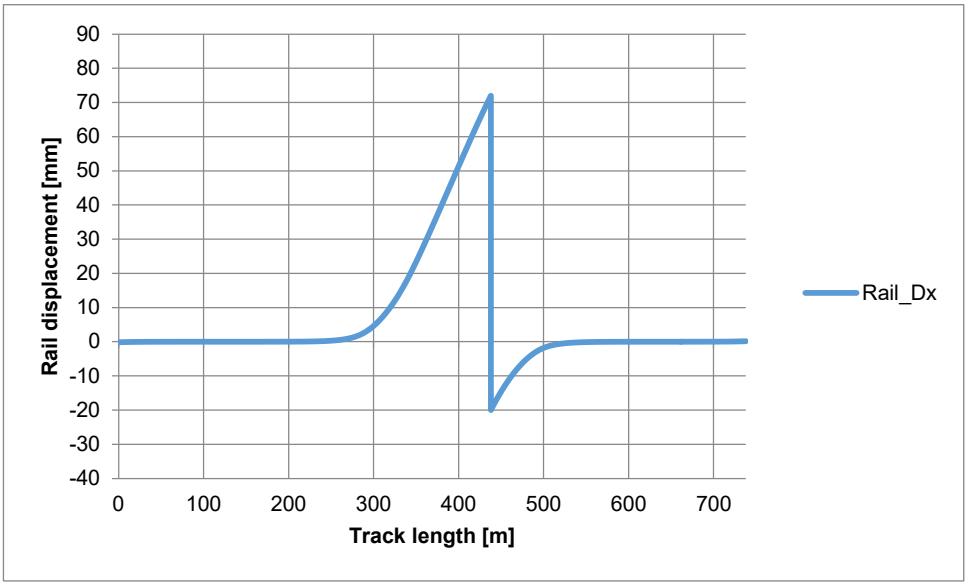


Maximum size of the gap due to cracking of the rail on the bridge in winter climatic conditions = **49,85 mm**

1.2.1.9 Capacity of the rail expansion device in the track on the bridge

The rail expansion device in the track is designed at km 0+865,33 in both tracks.

Summer climatic conditions



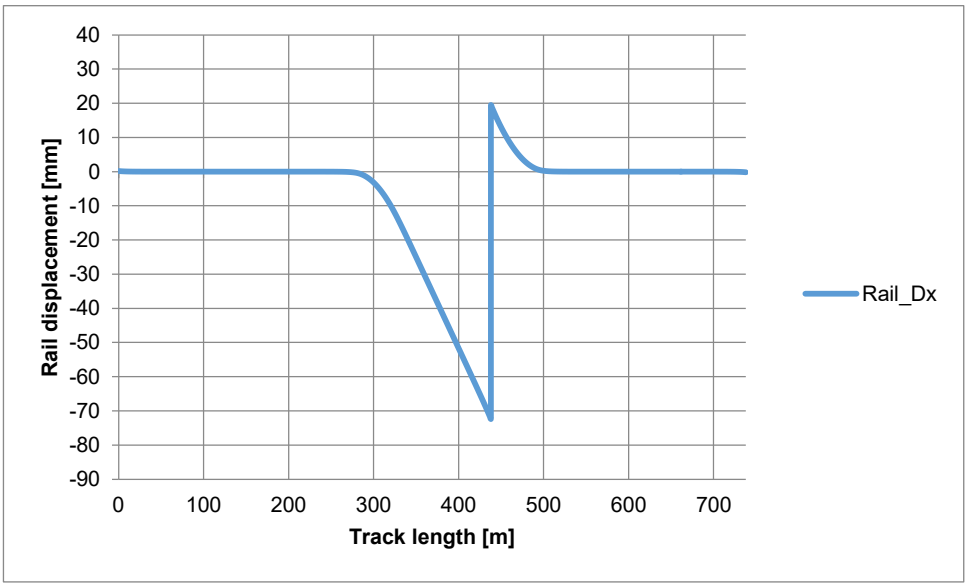
The maximum rail expansion on the bridge in summer climatic conditions **= +71,97 mm**

The maximum rail expansion on the bridge due to braking/acceleration **= +5,35 mm**

The maximum rail expansion on the bridge due to vertical train load **= +10,57 mm**

The total maximum rail expansion on the bridge = 1,5 x (+71,97 + 5,35 + 10,57) **= +131,84 mm**

Winter climatic conditions



The maximum rail contraction on the bridge in winter climatic conditions **= -72,40 mm**

The maximum rail contraction on the bridge due to braking/acceleration **= -4,59 mm**

The total maximum rail contraction on the bridge = 1,5 x (-72,40 - 4,95) **= -115,49 mm**

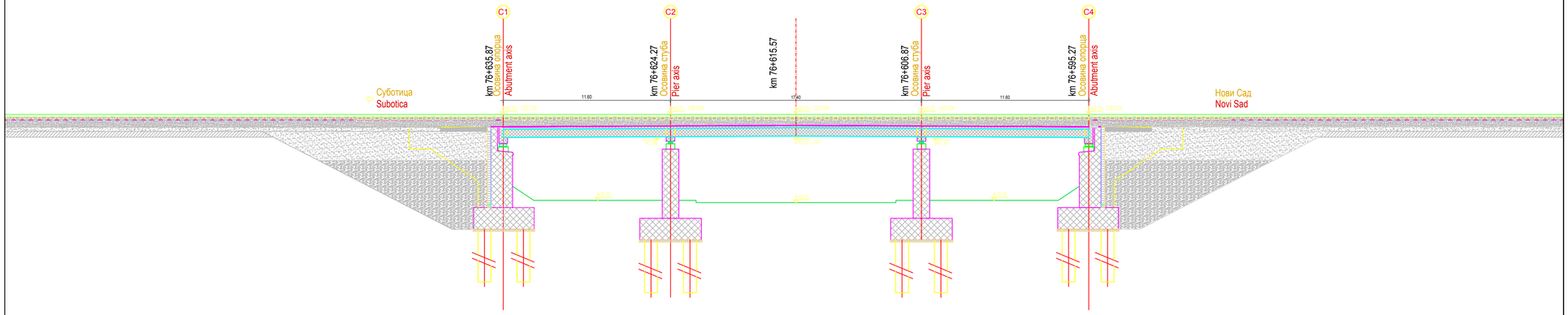
The installation of rail expansion devices in both tracks with a minimum capacity of **a = ±150 mm** at km 0+865.33 is required. (The capacity of the rail expansion device in the track is harmonized with the calculation of the bridge structure dilatation within the static calculation of the bridge.)

Calculated by:
Zoran Lukovic,dipl.gradj.inz.
licenca broj 310 3032 03

2/2-6.1.7.
GRAPHIC DOCUMENTATION

ПОДУЖНИ ПРЕСЕК МОСТА НА КМ 76+615.57 Д.К. (76+601.02 Л.К.)

LONGITUDINAL SECTION OF BRIDGE km 76+615,57



Број /Number	Датум / Date	Опис / Description
03		
02		
01		

Ревизиони блок: / Revision block:

САОБРАЋАЈНИ ИНСТИТУТ ЦИП, д.о.о.
INSTITUTE OF TRANSPORTATION CIP ltd
Немањина 6; 11000 Београд; Србија
Тел: 011/3618-134; Факс: 011/3618-324; web site: www.sicip.co.rs

Организациона јединица: САОБРАЋАЈНИЦЕ /Organization unit:DEPARTMENT OF ROADS AND RAILWAYS

Responsible designer:
Драгана Јокановић, дипл.инж.грађ.
лиценца број: / license No.: 315 1404 03

Сарадници: / Associates:

Инвеститор пројекта:
" ИНФРАСТРУКТУРА ЖЕЛЕЗНИЦЕ СРБИЈЕ " А.Д.
/ " INFRASTRUCTURE RAILWAYS OF SERBIA " JSC
Немањина 6/IV, Београд / Nemanjina Street 6/IV, Belgrade

Наручилац пројекта:
Joint Venture of
China Railway International Corporation Ltd. (CRIC)
No.10 Fuxing Road,Haidian District,Beijing
P.R China, 100844
China Communication Construction Company Ltd. (CCCC)
No.85 Deshengmenwai Street,Xicheng District,Beijing
P.R China, 100088

Објекат: /Structure:
ПРУГА БЕОГРАД - СУБОТИЦА - ДРЖАВНА ГРАНИЦА (КЕЛЕБИЈА)
ДЕОНИЦА ПРУГЕ НОВИ САД - СУБОТИЦА - ДРЖАВНА ГРАНИЦА (КЕЛЕБИЈА)
BELGRADE - SUBOTICA - STATE BORDER (KELEBIA) RAILWAY LINE
SECTION - NOVI SAD - SUBOTICA - STATE BORDER (KELEBIA)

Део пројекта: / Part of Design:
2/2.6.1 ПРОЈЕКАТ ГОРЊЕГ СТРОЈА ЗА МОСТОВСКЕ КОНСТРУКЦИЈЕ ДУЖИНЕ ПРЕКО 40М-ДЕОНИЦА НОВИ САД-РУМЕНКА ИЗЛАЗ
2/2.6.1 DESIGN OF SUPERSTRUCTURE FOR BRIDGE STRUCTURES LONGER THAN 40M SECTION NOVI SAD-RUMENKA ENTRY

Унутрашња контрола:
Милан Јелкић, дипл. грађ. инж.

Главни пројектант:
Др Љиљана Милић Марковић, дипл.грађ.инж.

Руководилац организационе јединице:
Manager of organization unit:
мр Новица Стевановић , дипл.инж.грађ.

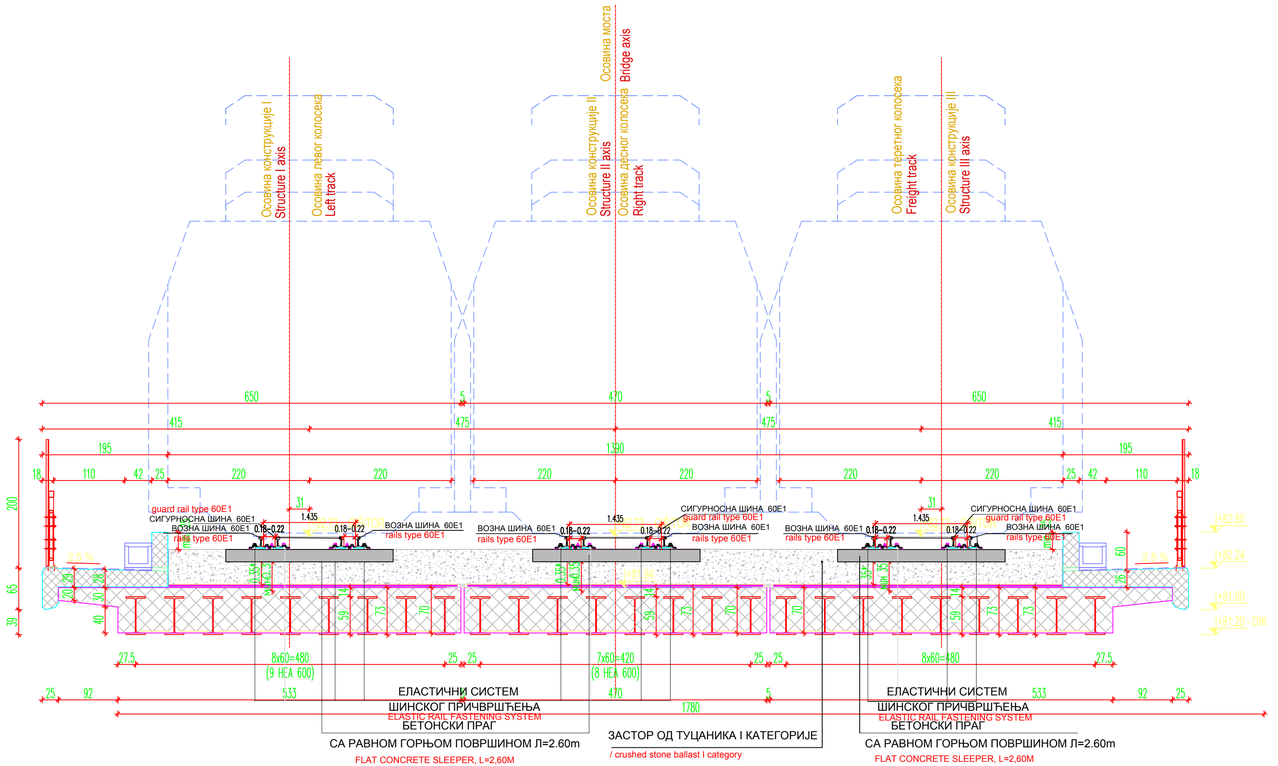
Цртеж: / Drawing: **ПОДУЖНИ ПРЕСЕК МОСТА НА КМ 76+615.57 Д.К. 76+601.02 Л.К.**
LONGITUDINAL PROFILE OF THE BRIDGE AT KM 76+615.57 R.T. (76+601.02 L.T.)

Размера: Scale: 1:200

Врста тех.док.: Type of tech.docum	датум:/date	Цртеж бр. /Drawing No.:
ПЗИ / DFC	08.2021	2020-250-CAO-2/2-6.1.7.1.1

ПОПРЕЧНИ ПРОФИЛ МОСТА НА КМ 76+615.57 Д.К. (76+601.02 Л.К.)

CROSS-SECTION OF BRIDGE km 76+615,57 R.T. (76+601.02 L.T.)



Број /Number	Датум / Date	Опис / Description
03		
02		
01		

Ревизиони блок:

САОБРАЋАЈНИ ИНСТИТУТ ЦИП, д.о.о.
INSTITUTE OF TRANSPORTATION CIP ltd
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Организациона јединица:САОБРАЋАЈНИЦЕ /Organization unit:DEPARTMENT OF ROADS AND RAILWAYS

Одговорни пројектант : Responsible designer:
Драгана Јокановић, дипл.инж.грађ.
лиценца број: / license No.: 315 1404 03

Сарадници: / Associates:

Инвеститор пројекта:
" ИНФРАСТРУКТУРА ЖЕЛЕЗНИЦЕ СРБИЈЕ " А.Д.
/ INFRASTRUCTURE RAILWAYS OF SERBIA " JSC
Немањина 6/IV, Београд / Nemanjina Street 6/IV, Belgrade

Научни пројекта: Joint Venture of
China Railway International Corporation Ltd. (CRIC) No.10 Fuxing Road Haidian District,Beijing P.R.China, 100044
China Communication Construction Company Ltd. (CCCC) No.85 Deshengmenwai Street,Xicheng District,Beijing P.R.China, 100088

Објекат: /Structure:
ПРУГА БЕОГРАД - СУБОТИЦА - ДРЖАВНА ГРАНИЦА (КЕЛЕБИЈА)
ДЕОНИЦА ПРУГЕ НОВИ САД - СУБОТИЦА - ДРЖАВНА ГРАНИЦА (КЕЛЕБИЈА)
BELGRADE - SUBOTICA - STATE BORDER (KELEBIA) RAILWAY LINE
SECTION : NOVI SAD - SUBOTICA - STATE BORDER (KELEBIA)

Део пројекта: / Part of Design:
2/2.6.1 ПРОЈЕКАТ ГОРЊЕГ СТРОЈА ЗА МОСТОВСКЕ КОНСТРУКЦИЈЕ ДУЖИНЕ ПРЕКО 40М-ДЕОНИЦА НОВИ САД-РУМЕНКА ИЗЛАЗ
2/2.6.1 DESIGN OF SUPERSTRUCTURE FOR BRIDGE STRUCTURES LONGER THAN 40M SECTION NOVI SAD-RUMENKA ENTRY

Унутрашња контрола: / Internal control:
Милан Јелкић, дипл. грађ. инж.

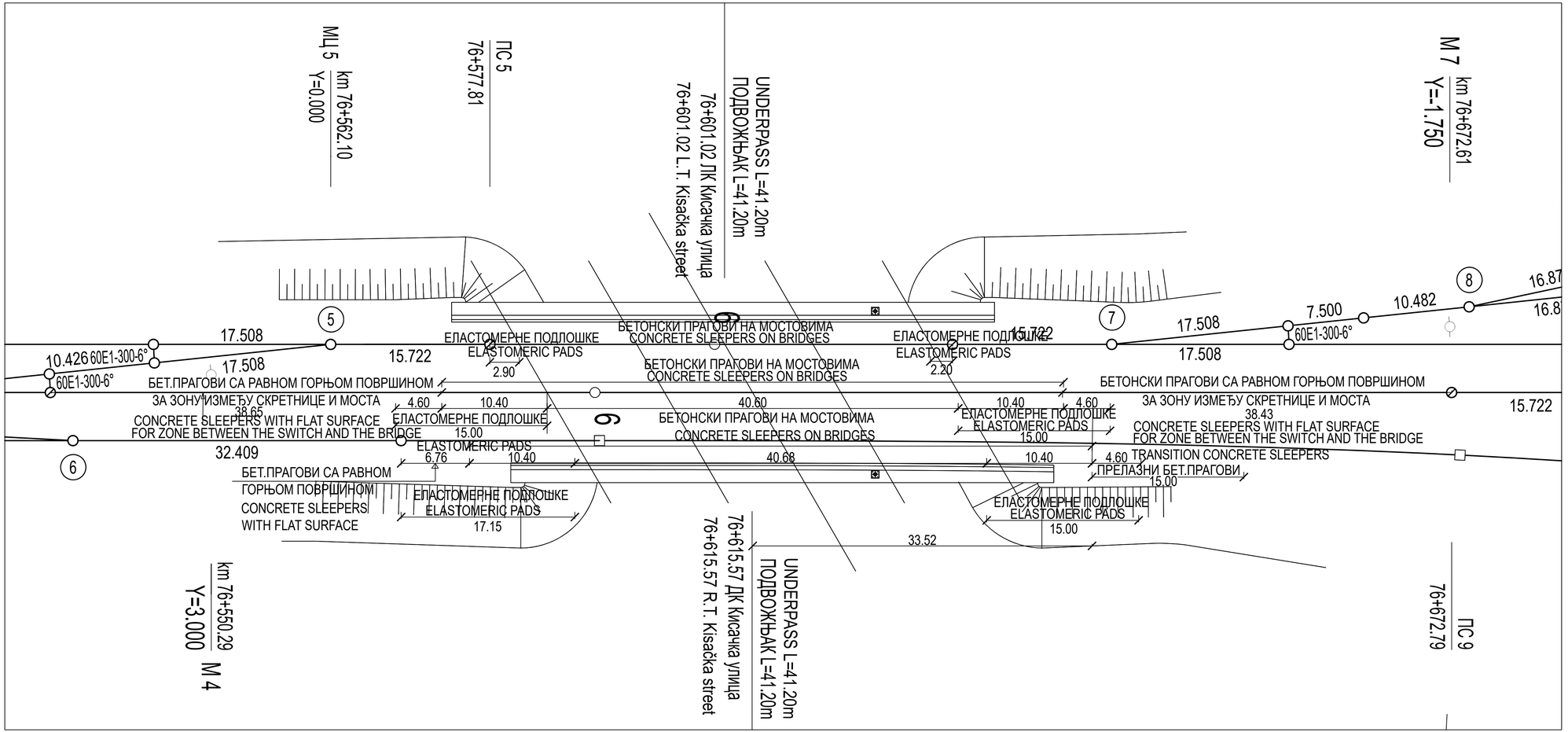
Главни пројектант: / Chief designer:
Др Љиљана,Милић,Марковић, дипл.грађ.инж.

Руководилац организационе јединице:
Manager of organization unit:
мр Новица Стевановић , дипл.инж.грађ.

Цртеж: Drawing: **ПОПРЕЧНИ ПРОФИЛ МОСТА НА КМ 76+615.57 Д.К. (76+601.02 Л.К.)**
CROSS SECTION OF THE BRIDGE AT KM 76+615,57 R.T. (76+601.02 L.T.)

Размера: Scale: **1:50**

Врста тех.док.: Type of tech.docum.	*Датум/date*	*Цртеж бр./Drawing No.:*
ПЗИ / DFC	**08.2021**	*2020-250-САО-2/2-6.1.7.1.2*



Број /Number	Датум / Date	Опис / Description
03		
02		
01		

Ревизиони блок: / Revision block:

САОБРАЋАЈНИ ИНСТИТУТ ЦИП, д.о.о.
INSTITUTE OF TRANSPORTATION CIP ltd
Немањина 6; 11000 Београд; Србија
Тел: 011/3618-134; Факс: 011/3618-324; web site: www.sicip.co.rs

Организациона јединица:САОБРАЋАЈНИЦЕ/Organization unit:DEPARTMENT OF ROADS AND RAILWAYS

Одговорни пројектант : / Responsible designer:
Драгана Јокановић, дипл.инж.грађ.
лиценца број: / license No.:315 1404 03
Драгана Јокановић, дипл.инж.грађ.

Сарадници: / Associates:

Инвеститор пројекта:
" ИНФРАСТРУКТУРА ЖЕЛЕЗНИЦЕ СРБИЈЕ " А.Д.
/ " INFRASTRUCTURE RAILWAYS OF SERBIA " JSC
Немањина 6/IV, Београд / Nemanjina Street 6/IV, Belgrade

Наручилац пројекта: Joint Venture of
China Railway International Corporation Ltd. (CRIC)
No.10 Fuxing Road,Haidian District,Beijing
P.R China, 100044
China Communication Construction Company Ltd. (CCCC)
No.85 Deshengmenwai Street,Xicheng District,Beijing
P.R China, 100088

Објекат: /Structure:
ПРУГА БЕОГРАД - СУБОТИЦА - ДРЖАВНА ГРАНИЦА (КЕЛЕБИЈА)
ДЕОНИЦА ПРУГЕ НОВИ САД - СУБОТИЦА - ДРЖАВНА ГРАНИЦА (КЕЛЕБИЈА)
BELGRADE - SUBOTICA - STATE BORDER (KELEBIA) RAILWAY LINE
SECTION : NOVI SAD - SUBOTICA - STATE BORDER (KELEBIA)

Део пројекта:
2/2.6.1 ПРОЈЕКАТ ГОРЊЕГ СТРОЈА ЗА МОСТОВСКЕ КОНСТРУКЦИЈЕ ДУЖИНЕ ПРЕКО 40М-ДЕОНИЦА НОВИ САД-РУМЕНКА ИЗЛАЗ
2/2.6.1 DESIGN OF SUPERSTRUCTURE FOR BRIDGE STRUCTURES LONGER THAN 40M SECTION NOVI SAD-RUMENKA ENTRY

Унутрашња контрола:
Милан Јелкић, дипл. грађ. инж.

Главни пројектант:
Др Љиљана,Милић,Марковић, дипл.грађ.инж.

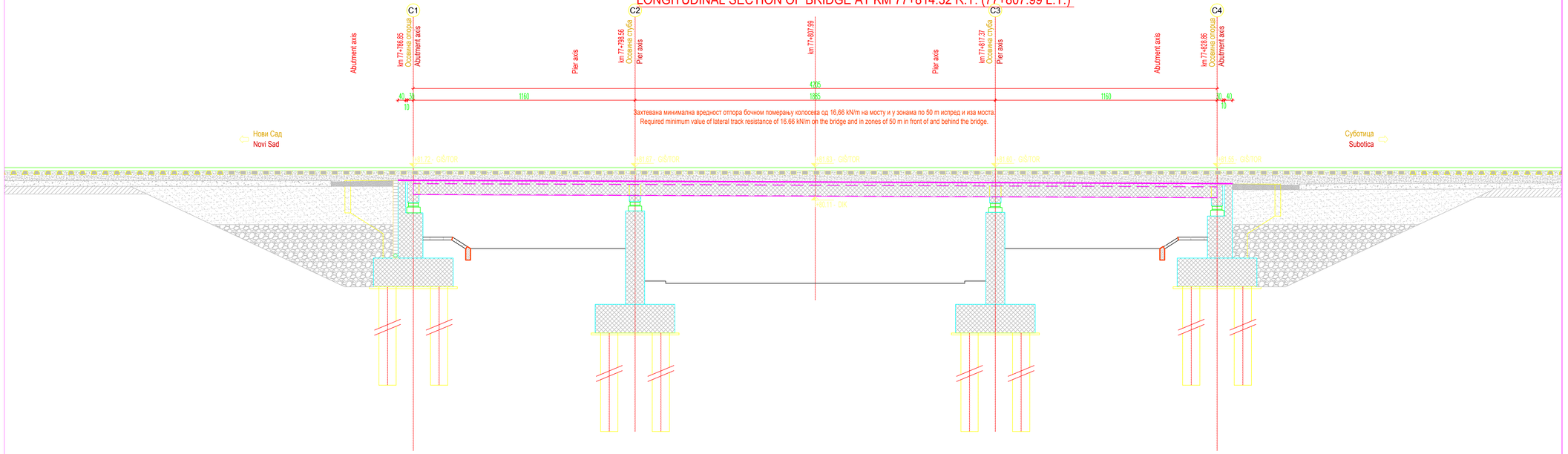
Руководилац организационе јединице:
Manager of organization unit:
мр Новица Стевановић , дипл.инж.грађ.

Цртеж:/ Drawing: **положај ЕЛАСТОМЕРНИХ ПОДЛОШКИ ЗА МОСТ НА КМ 76+615,57 Д.К. (76+601,02 Л.К.)**
POSITION OF ELASTHOMERIC PADS FOR BRIDGE ON KM 76+615,57 Right track (76+601,02 Left track)

Размера: Scale: 1:250

Врста тех.док.: Type of tech.docum.: **ПЗИ / DFC**
датум/date: **08.2021**
Цртеж бр. /Drawing No.: **2020-250-САО-2/2-6.1.7.1.3**

ПОДУЖНИ ПРЕСЕК МОСТА НА КМ 77+814.32 Д.К. (77+807.99 Л.К.)
LONGITUDINAL SECTION OF BRIDGE AT KM 77+814.32 R.T. (77+807.99 L.T.)



03		
02		
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Број /Number	Датум / Date	Опис / Description

Ревизиони блок: / Revision block:

САОБРАЋАЈНИ ИНСТИТУТ ЦИП, д.о.о.
INSTITUTE OF TRANSPORTATION CIP ltd
Немањина 6; 11000 Београд; Србија
Тел: 011/3618-134; Факс: 011/3618-324; web site: www.sicip.co.rs

Организациона јединица:САОБРАЋАЈНИЦЕ/Organization unit:DEPARTMENT OF ROADS AND RAILWAYS

Responsible designer:
Драгана Јокановић, дипл.инж.грађ.
лиценца број: / license No.: *315 1404 03*

Сарадници: / Associates:

Инвеститор пројекта:
" ИНФРАСТРУКТУРА ЖЕЛЕЗНИЦЕ СРБИЈЕ " АД
" INFRASTRUCTURE RAILWAYS OF SERBIA " JSC
Немањина 6/IV, Београд, / Nemanjina Street 6/IV, Belgrade

Project Drawing: **ПОДУЖНИ ПРЕСЕК МОСТА НА КМ 77+814.32 Д.К. (77+807.99 Л.К.)**
LONGITUDINAL PROFILE OF THE BRIDGE AT KM 77+814.320 T. (77+807.99 L.T.)

Scale: 1:200

Врста тех.док.: / Type of tech.docum: ПЗИ / DFC

Датум/Date: 08.2021

Пројекат бр./Drawing No.: 2020-250-САО-2/2-6.1.7.2.1

Руководилац организационе јединице: / Manager of organization unit:
мр Новица Стевановић , дипл.инж.грађ.

Главни пројектант:
Др Љиљана Милић Марковић, дипл.грађ. инж.

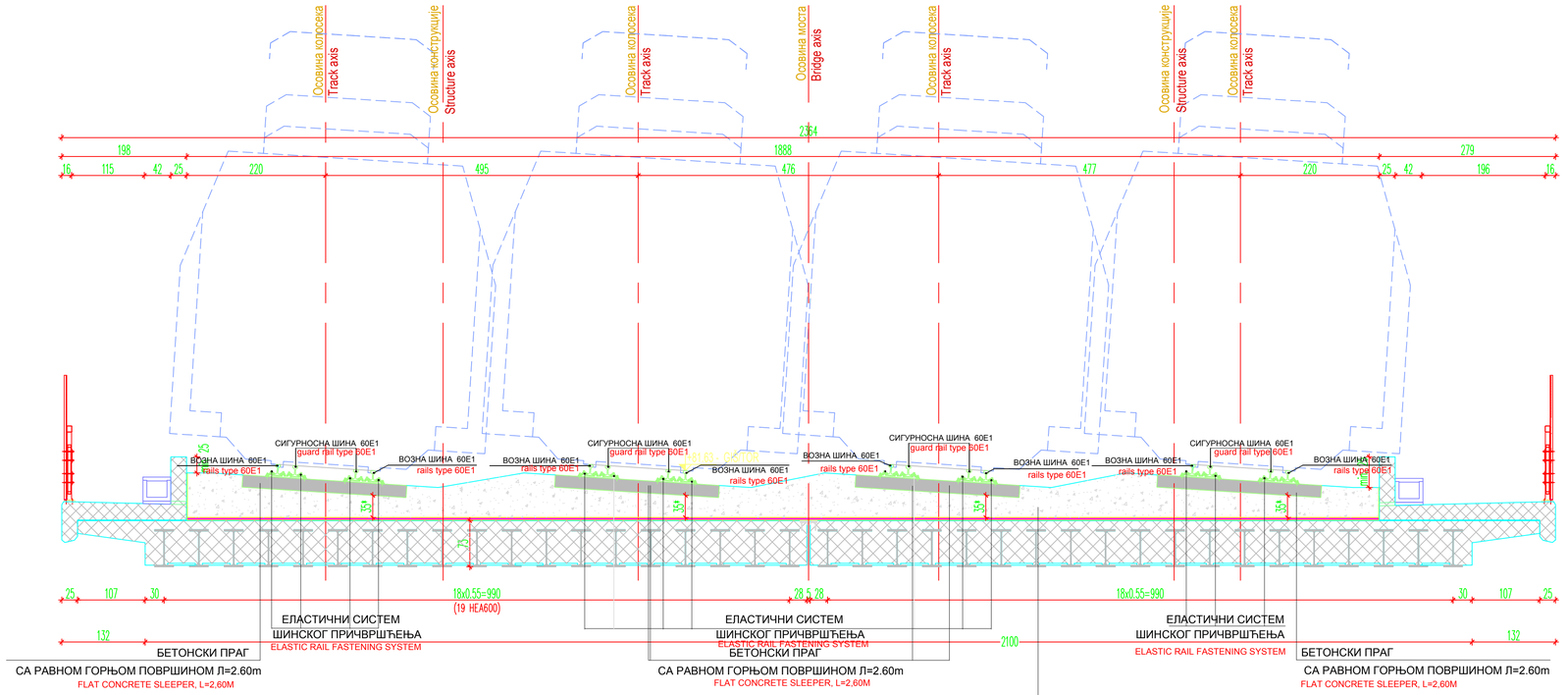
Одговорни пројектант:
Милан Јелкић, дипл. грађ. инж.

Објекат: / Structure:
ПРУГА БЕОГРАД - СУБОТИЦА - ДРЖАВНА ГРАНИЦА (КЕЛЕБИЈА)
ДЕОНИЦА ПРУГЕ НОВИ САД - СУБОТИЦА - ДРЖАВНА ГРАНИЦА (КЕЛЕБИЈА)
BELGRADE - SUBOTICA - STATE BORDER (KELEBIA) RAILWAY LINE
SECTION: NOVI SAD - SUBOTICA - STATE BORDER (KELEBIA)

Део пројекта: / Part of Design:
2/2.6 / ПРОЈЕКАТ ГОРЊЕГ СТРОЈА ЗА МОСТОВСКЕ КОНСТРУКЦИЈЕ ДУЖИНЕ ПРЕКО 40М-ДЕОНИЦА НОВИ САД-РУМЕНКА УЛАЗ
2/2.6.1 DESIGN OF SUPERSTRUCTURE FOR BRIDGE STRUCTURES LONGER THAN 40M SECTION NOVI SAD-RUMENKA ENTRY

ПОПРЕЧНИ ПРОФИЛ МОСТА НА КМ 77+814.32 Д.К. (77+807.99 Л.К.)

CROSS-SECTION OF BRIDGE km 77+814,32 R.T. (77+807.99 L.T.)



03		
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Број /Number	Датум / Date	Опис / Description

Ревизиони блок:

САОБРАЋАЈНИ ИНСТИТУТ ЦИП, д.о.о.
INSTITUTE OF TRANSPORTATION CIP ltd
Немањина 6; 11000 Београд; Србија
Тел: 011/3618-134; Факс: 011/3618-324; web site: www.sicip.co.rs

Организациона јединица:САОБРАЋАЈНИЦЕ /Organization unit:DEPARTMENT OF ROADS AND RAILWAYS

Одговорни пројектант : / Responsible designer:
Драгана Јокановић, дипл.инж.грађ.
лиценца број: / license No.: *315 1404 03*
Драгана Јокановић, дипл.инж.грађ.

Сарадници: / Associates:

Инвеститор пројекта: / Investitor of project:
" ИНФРАСТРУКТУРА ЖЕЛЕЗНИЦЕ СРБИЈЕ " А.Д.
" INFRASTRUCTURE RAILWAYS OF SERBIA " JSC
Немањина 6/IV, Београд / Nemanjina Street 6/IV, Belgrade

Пројектант пројекта: / Designer of project:
Joint Venture of
China Railway International Corporation Ltd. (CRIC)
No.10 Fuxing Road,Haidian District,Beijing
P.R.China, 100044
China Communication Construction Company Ltd. (CCCC)
No.85 Deshengmenwai Street,Xicheng District,Beijing
P.R.China, 100088

Објекат: / Structure:
ПРУГА БЕОГРАД - СУБОТИЦА - ДРЖАВНА ГРАНИЦА (КЕЛЕБИЈА)
ДЕОНИЦА ПРУГЕ НОВИ САД - СУБОТИЦА - ДРЖАВНА ГРАНИЦА (КЕЛЕБИЈА)
BELGRADE - SUBOTICA - STATE BORDER (KELEBIA) RAILWAY LINE
SECTION : NOVI SAD - SUBOTICA - STATE BORDER (KELEBIA)

Део пројекта: / Part of Design:
2/2.6./ ПРОЈЕКАТ ГОРЊЕГ СТРОЈА ЗА МОСТОВСКЕ КОНСТРУКЦИЈЕ ДУЖИНЕ ПРЕКО 40М-ДЕОНИЦА НОВИ САД-РУМЕНКА ИЗЛАЗ
2/2.6.1 DESIGN OF SUPERSTRUCTURE FOR BRIDGE STRUCTURES LONGER THAN 40M SECTION NOVI SAD-RUMENKA ENTRY

Унутрашња контрола: / Internal control:
Милан Јелкић, дипл. грађ. инж.

Цртеж: **ПОПРЕЧНИ ПРОФИЛ МОСТА НА КМ 77+814.32 Д.К. (77+807.99 Л.К.)**
CROSS SECTION OF THE BRIDGE AT KM 77+814,32 R.T. (77+807.99 L.T.)

Размера: Scale: *1:50*

Главни пројектант: / Chief designer:
Др Љиљана,Милић,Марковић, дипл.грађ.инж.

Руководилац организационе јединице: Manager of organization unit:
мр Новица Стевановић , дипл.инж.грађ.

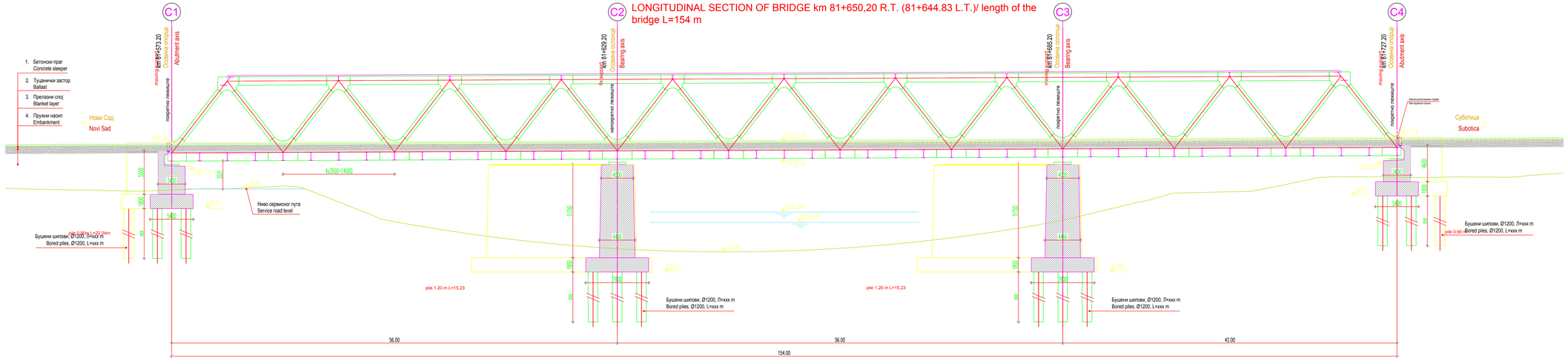
Врста тех.док.: Type of tech.docum
ПЗИ / DFC

датум/date: **08.2021**

Цртеж бр./Drawing No.: *2020-250-САО-2/2-6.1.7.2.2*

ПОДУЖНИ ПРЕСЕК МОСТА НА КМ 81+650.20 Д.К. (81+644.83Л.К.) Л=154.00м

LONGITUDINAL SECTION OF BRIDGE km 81+650,20 R.T. (81+644.83 L.T.)/ length of the bridge L=154 m



Број /Number	Датум / Date	Опис / Description
03		
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01		

Ревизиони блок: / Revision block

САОБРАЋАЈНИ ИНСТИТУТ ЦИП, д.о.о.
INSTITUTE OF TRANSPORTATION CIP ltd
Немањина 6; 11000 Београд; Србија
Тел: 011/3618-134; Факс: 011/3618-324; web site: www.sicip.co.rs

Организациона јединица:САОБРАЋАЈНИЦЕ /Organization unit:DEPARTMENT OF ROADS AND RAILWAYS

Responsible designer:
Драгана Јокановић, дипл.инж.грађ, лиценца број / license No.: 315 1404 03

Сарадници: / Associates:

Инвеститор пројекта:
ИНФРАСТРУКТУРА ЖЕЛЕЗНИЦЕ СРБИЈЕ а.д.
Немањина 6/II, Београд / Nemanjina Street 6/II, Belgrade

Ортачко предузеће / Joint Venture of
China Railway International Corporation Ltd. (CRIC)
Room 1001, Tower A, Fuhua Mansion, No.8 Chaoyangmen North Street,Dongcheng District,Beijing, P.R.China, 100027

China Communications Construction Company Ltd. (CCCC)
No.85,Deshengwai Street,Xicheng District,Beijing, P.R.China, 100088

Објекат: / Object:
ПРУГА БЕОГРАД - СУБОТИЦА - ДРЖАВНА ГРАНИЦА (КЕЛЕБИЈА)
ДЕОНИЦА ПРУГЕ НОВИ САД - СУБОТИЦА - ДРЖАВНА ГРАНИЦА (КЕЛЕБИЈА)
BELGRADE - SUBOTICA - STATE BORDER (KELEBIA) RAILWAY LINE
SECTION: NOVI SAD - SUBOTICA - STATE BORDER (KELEBIA)

Део пројекта: / Part of Design:
2/2.6.1 ПРОЈЕКАТ ГОРЊЕГ СТРОЈА ЗА МОСТОВСКЕ КОНСТРУКЦИЈЕ ДУЖИНЕ ПРЕКО 40М ДЕОНИЦА НОВИ САД-РУМЕНКА ИЗЛАЗ
2/2.6.1 DESIGN OF SUPERSTRUCTURE FOR BRIDGE STRUCTURES LONGER THAN 40M SECTION NOVI SAD-RUMENKA EXITY

Унутрашња контрола:
Милан Јелић, дипл. грађ. инж.

Главни пројектант:
Др Љиљана Милић Марковић, дипл.грађ.инж.

Руководилац организационе јединице:
Manager of organization unit
мр Новица Стевановић , дипл.инж.грађ.

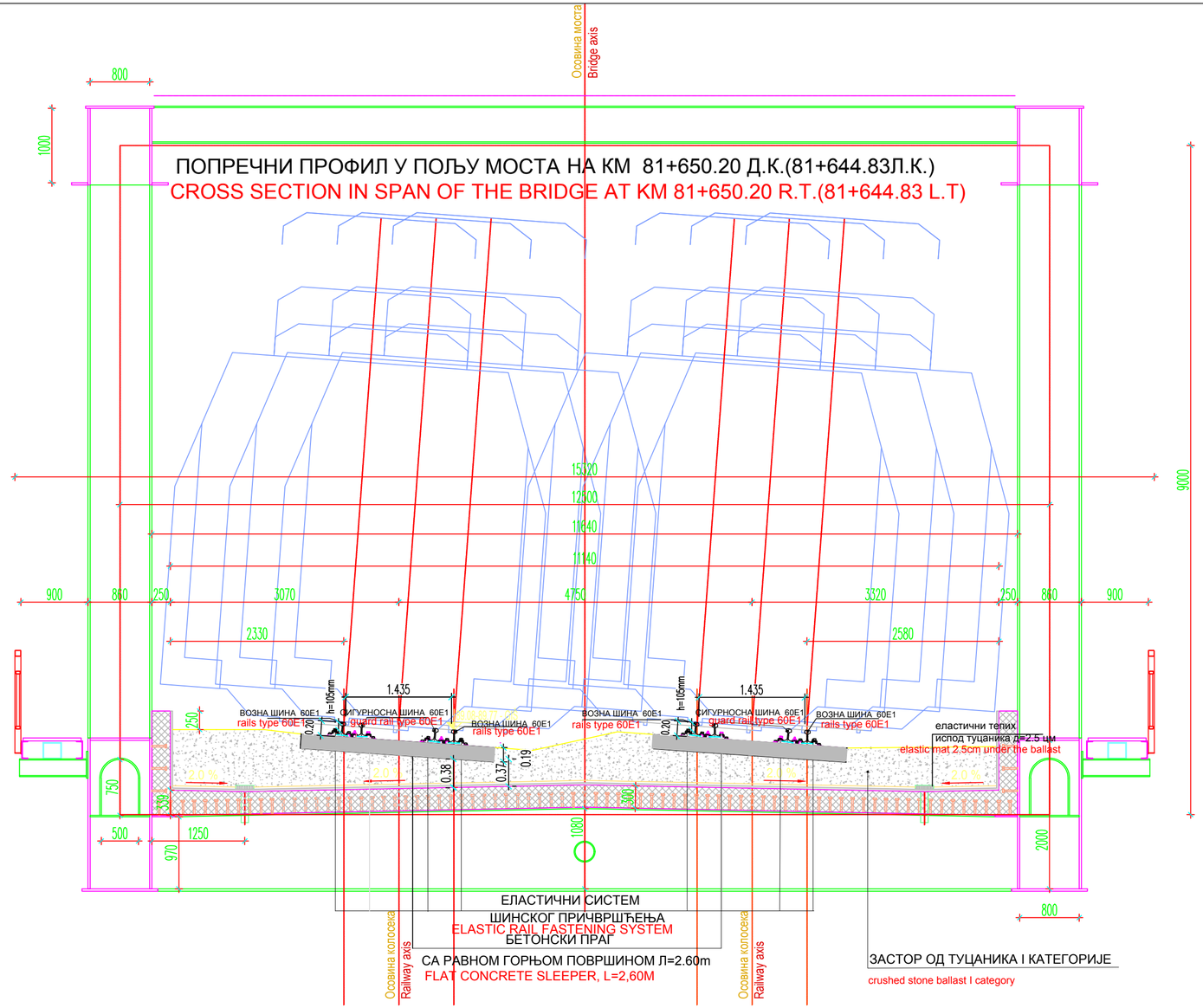
Цртеж: / Drawing:
ПОДУЖНИ ПРЕСЕК МОСТА НА КМ 81+650 Д.К. (81+644.83Л.К.)
LONGITUDINAL SECTION OF BRIDGE
AT KM 81+650.20 R.T. (81+644.83 L.T.)

Размера: Scale: 1:200

Врста тех.док.: Type of tech.docum.: ПЗИ / DPC

Датум: Date: 08.2021

Цртеж бр.: /Drawing No.: 2020-250-CAO-2/2.6.1.7.3.1



ПОПРЕЧНИ ПРОФИЛ У ПОЉУ МОСТА НА КМ 81+650.20 Д.К.(81+644.83Л.К.)

CROSS SECTION IN SPAN OF THE BRIDGE AT KM 81+650.20 R.T.(81+644.83 L.T)

Број /Number	Датум / Date	Опис / Description
03		
02		
01		

Ревизиони блок:

САОБРАЋАЈНИ ИНСТИТУТ ЦИП, д.о.о.
INSTITUTE OF TRANSPORTATION CIP ltd
Немањина 6; 11000 Београд; Србија
Тел: 011/3618-134; Факс: 011/3618-324; web site: www.sicip.co.rs

Организациона јединица:САОБРАЋАЈНИЦЕ /Organization unit:DEPARTMENT OF ROADS AND RAILWAYS

Одговорни пројектант :
Responsible designer:
Драгана Јокановић, дипл.инж.грађ.
лиценца број: / license No.: 315 1404 03

Сарадници: / Associates:

Инвеститор пројекта:
" ИНФРАСТРУКТУРА ЖЕЛЕЗНИЦЕ СРБИЈЕ " А.Д.
/ " INFRASTRUCTURE RAILWAYS OF SERBIA " JSC
Немањина 6/IV, Београд / Nemanjina Street 6/IV, Belgrade

Наручилац пројекта:
Joint Venture of
China Railway International Corporation Ltd. (CRIC)
No.10 Fuxing Road,Haidian District,Beijing
P.R China, 100844
China Communication Construction Company Ltd. (CCCC)
No.85 Deshengmenwai Street,Xicheng District,Beijing
P.R China, 100088

Објекат: /Structure:
ПРУГА БЕОГРАД - СУБОТИЦА - ДРЖАВНА ГРАНИЦА (КЕЛЕБИЈА)
ДЕОНИЦА ПРУГЕ НОВИ САД - СУБОТИЦА - ДРЖАВНА ГРАНИЦА (КЕЛЕБИЈА)
BELGRADE - SUBOTICA - STATE BORDER (KELEBIA) RAILWAY LINE
SECTION : NOVI SAD - SUBOTICA - STATE BORDER (KELEBIA)

Део пројекта: / Part of Design:
2/2.6.1 ПРОЈЕКАТ ГОРЊЕГ СТРОЈА ЗА МОСТОВСКЕ КОНСТРУКЦИЈЕ ДУЖИНЕ ПРЕКО 40М-ДЕОНИЦА НОВИ САД-РУМЕНКА ИЗЛАЗ
2/2.6.1 DESIGN OF SUPERSTRUCTURE FOR BRIDGE STRUCTURES LONGER THAN 40M SECTION NOVI SAD-RUMENKA ENTRY

Унутрашња контрола: / Internal control:
Милан Јелкић, дипл. грађ. инж.

Главни пројектант: / Chief designer:
Др Љиљана Милић Марковић, дипл.грађ.инж.

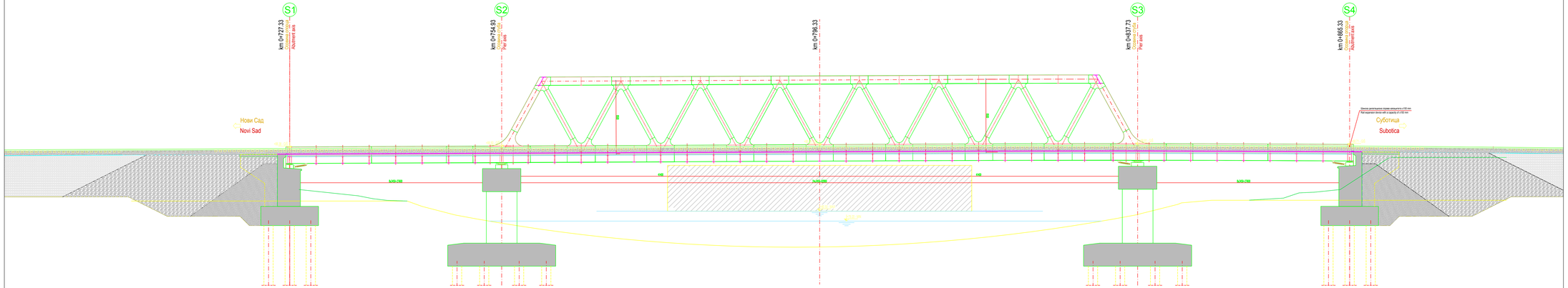
Руководилац организационе јединице:
Manager of organization unit:
мр Новица Стевановић , дипл.инж.грађ.

Цртеж: / Drawing:
ПОПРЕЧНИ ПРОФИЛ МОСТА НА КМ 81+650.20Д.К.(81+644.83Л.К.)
CROSS SECTION OF THE BRIDGE AT KM 81+650.20 R.T. (81+644.83 L.T.)

Размера: Scale: 1:50

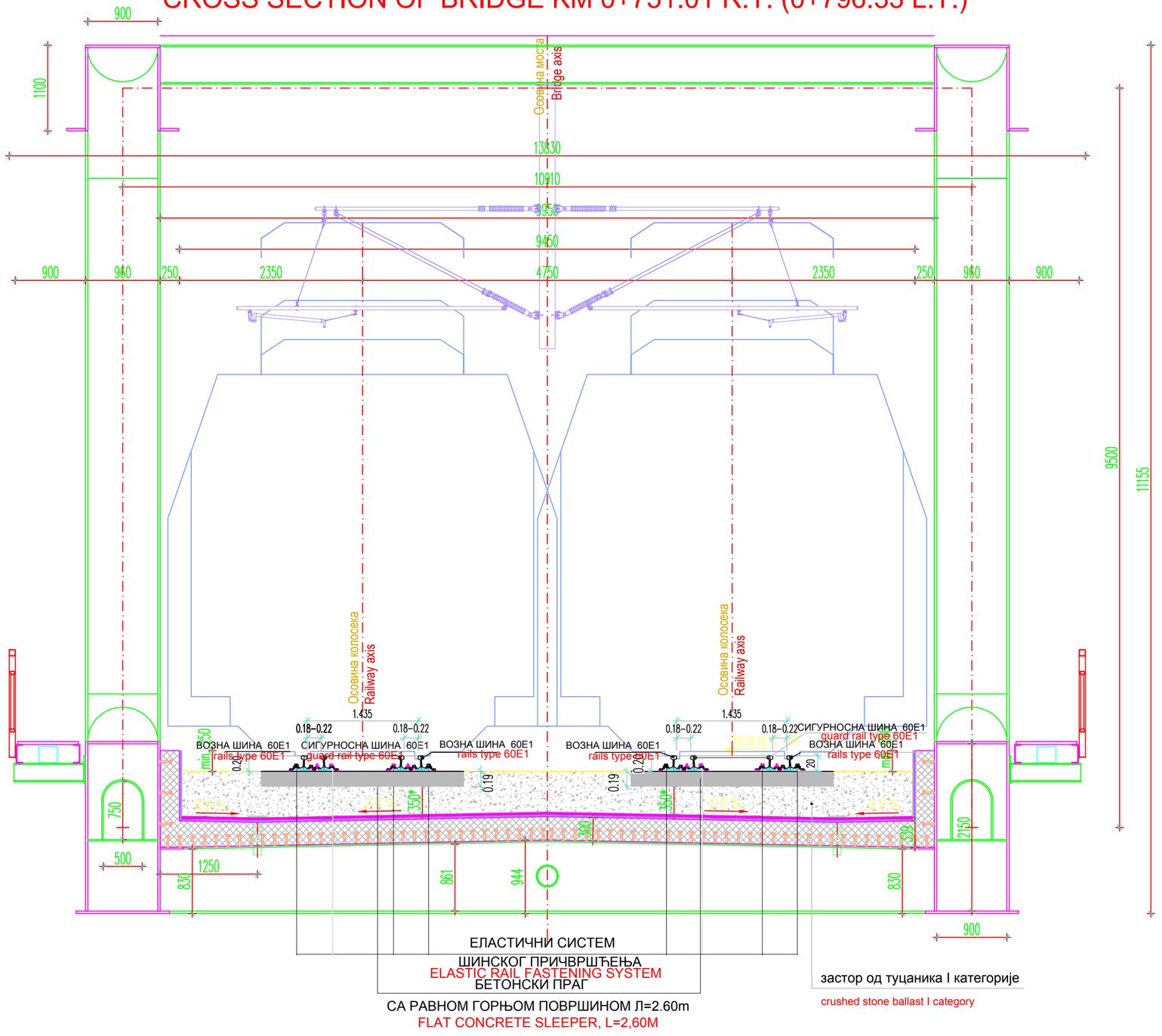
Врста тех.док.: Type of tech.docum.	датум:/date	Цртеж бр. /Drawing No.:
ПЗИ / DFC	**08.2021**	2020-250-САО-2/2-6.1.7.3.2

ПОДУЖНИ ПРЕСЕК МОСТА НА КМ 0+751.01 Д.К. (0+796.33 Л.К.)
LONGITUDINAL SECTION OF BRIDGE km R.T. 0+751,01 (0+796.33 L.T.)


S1
km 0+727.33
Abutment axis
S2
km 0+754.93
Pier axis
km 0+796.33
S3
km 0+837.73
Pier axis
S4
km 0+865.33
Abutment axis
Нови Сад
Novi Sad
Суботица
Subotica
Škola gimnazijskog nivoa sekcijama u ITD km
Rail segment decline with a capacity of 200 km
L=43.560
L=56.720
L=43.560
L=43.560
L=56.720
L=43.560
L=43.560
L=56.720
L=43.560

ПОПРЕЧНИ ПРОФИЛ МОСТА НА КМ 0+751.01 Д.К. (0+796.33Л.К.)

CROSS SECTION OF BRIDGE KM 0+751.01 R.T. (0+796.33 L.T.)



ЕЛАСТИЧНИ СИСТЕМ
ШИНСКОГ ПРИЧВРШЋЕЊА
ELASTIC RAIL FASTENING SYSTEM
БЕТОНСКИ ПРАГ
СА РАВНОМ ГОРЊОМ ПОВРШИНОМ Л=2.60m
FLAT CONCRETE SLEEPER, L=2,60M

застор од туцаника I категорије
crushed stone ballast I category

Број /Number	Датум / Date	Опис / Description
03		
02		
01		

Ревизиони блок:

САОБРАЋАЈНИ ИНСТИТУТ ЦИП, д.о.о.
INSTITUTE OF TRANSPORTATION CIP ltd
Немањина 6; 11000 Београд; Србија
Тел: 011/3618-134; Факс: 011/3618-324; web site: www.sicip.co.rs

Организациона јединица:САОБРАЋАЈНИЦЕ /Organization unit:DEPARTMENT OF ROADS AND RAILWAYS

Одговорни пројектант :
Responsible designer:
Драгана Јокановић, дипл.инж.грађ.
лиценца број: / license No.: 315 1404 03

Сарадници: / Associates:

Унутрашња контрола: / Internal control:

Главни пројектант:
Др Љиљана Милић Марковић, дипл.грађ.инж.

Руководилац организационе јединице:
мр Новица Стевановић , дипл.инж.грађ.

Инвеститор пројекта:
" ИНФРАСТРУКТУРА ЖЕЛЕЗНИЦЕ СРБИЈЕ " А.Д.
/" INFRASTRUCTURE RAILWAYS OF SERBIA " JSC
Немањина 6/IV, Београд / Nemanjina Street 6/IV, Belgrade

Наручилац пројекта: Joint Venture of
China Railway International Corporation Ltd. (CRIC)
No.10 Fuxing Road,Haidian District,Beijing
P.R China, 100844
China Communication Construction Company Ltd. (CCCC)
No.85 Deshengmenwai Street,Xicheng District,Beijing
P.R China, 100088

Објекат: /Structure:
ПРУГА БЕОГРАД - СУБОТИЦА - ДРЖАВНА ГРАНИЦА (КЕЛЕБИЈА)
ДЕОНИЦА ПРУГЕ НОВИ САД - СУБОТИЦА - ДРЖАВНА ГРАНИЦА (КЕЛЕБИЈА)
BELGRADE - SUBOTICA - STATE BORDER (KELEBIA) RAILWAY LINE
SECTION : NOVI SAD - SUBOTICA - STATE BORDER (KELEBIA)

Део пројекта: / Part of Design:
2/2.6.1 ПРОЈЕКАТ ГОРЊЕГ СТРОЈА ЗА МОСТОВСКЕ КОНСТРУКЦИЈЕ ДУЖИНЕ ПРЕКО 40М-ДЕОНИЦА НОВИ САД-РУМЕНКА ИЗЛАЗ
2/2.6.1 DESIGN OF SUPERSTRUCTURE FOR BRIDGE STRUCTURES LONGER THAN 40M SECTION NOVI SAD-RUMENKA ENTRY

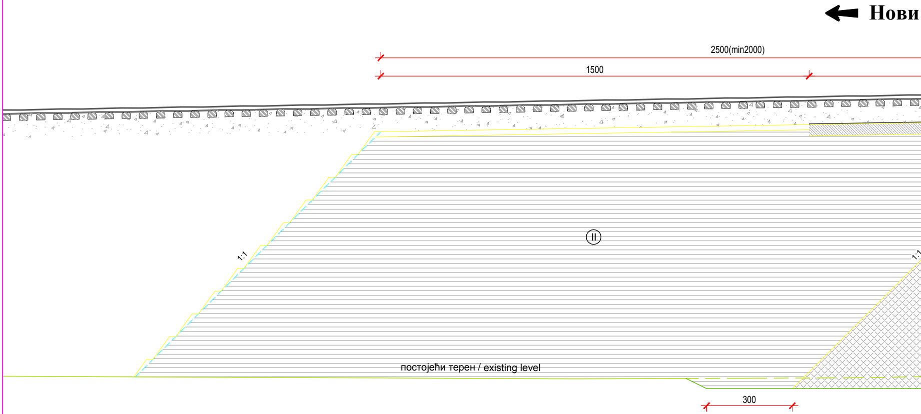
Цртеж: / Drawing: **ПОПРЕЧНИ ПРОФИЛ МОСТА НА КМ 0+751.01 Д.К. (0+796.33 Л.К.)**
CROSS SECTION OF THE BRIDGE AT KM 0+751.01 R.T. (0+796.33 L.T.)

Размера: Scale: 1:50

Фаза пројекта: Type of tech.docum.: **ПЗИ** / DFC

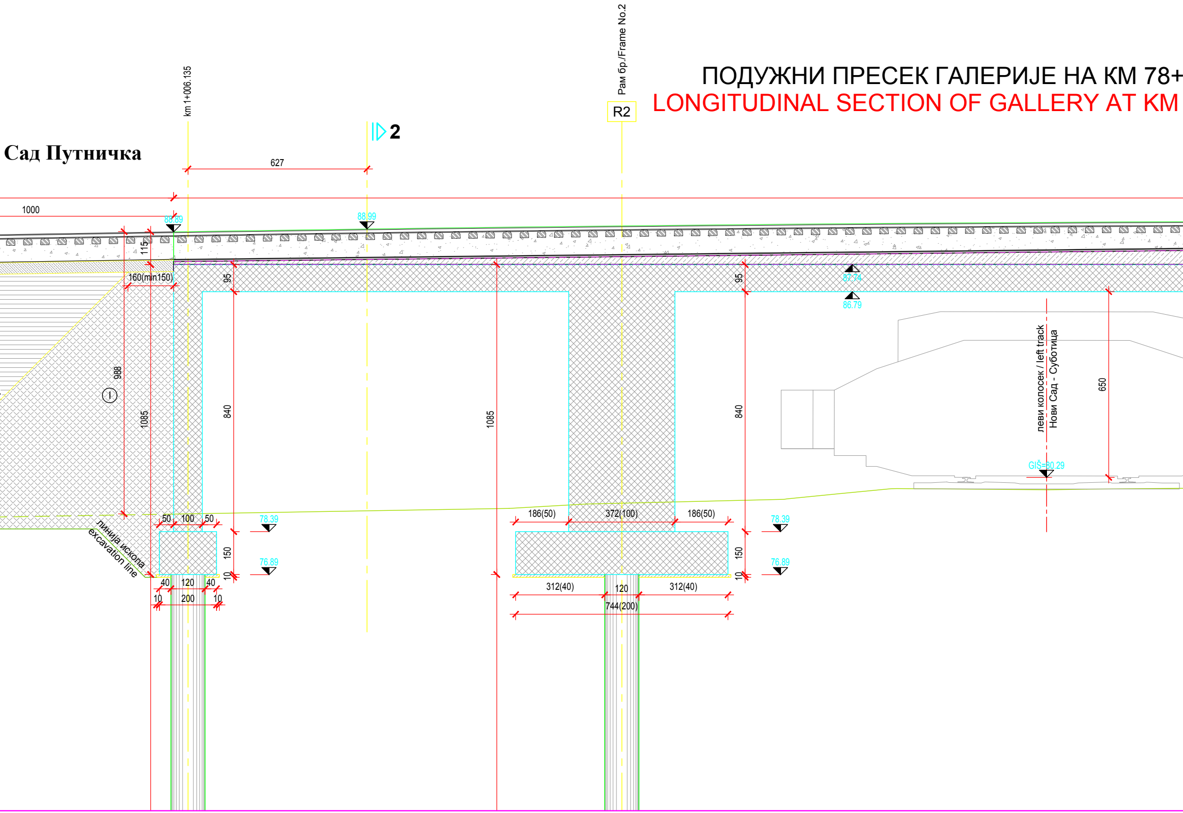
датум:/date: **08.2021**

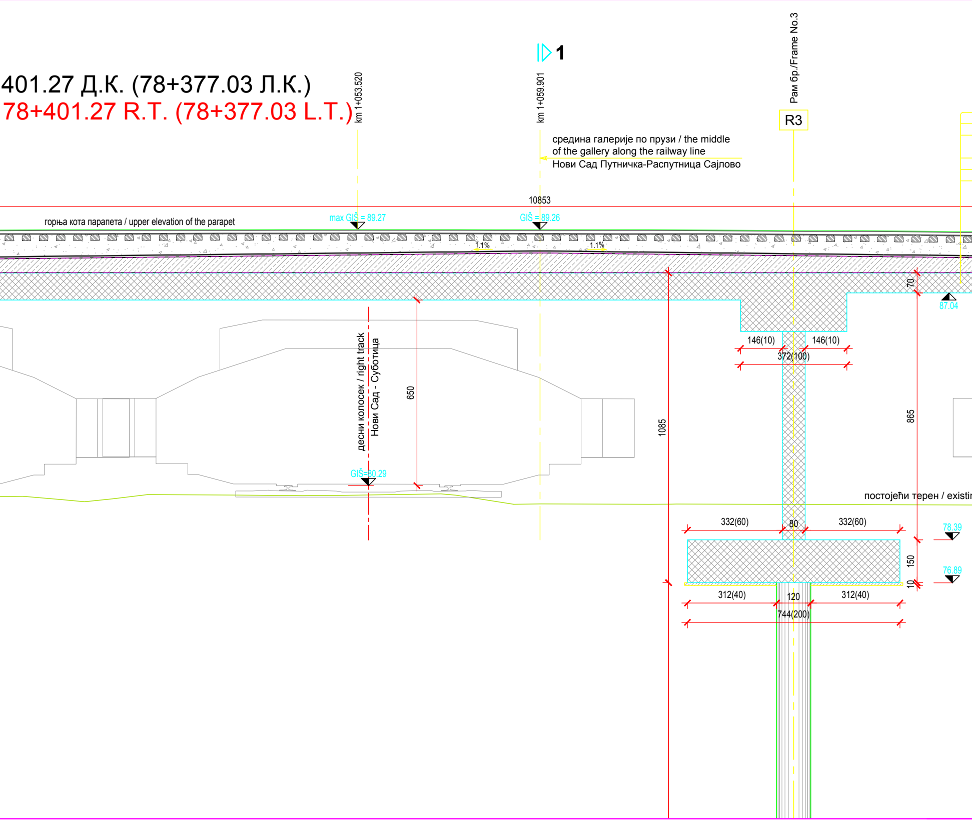
Цртеж бр. /Drawing No.: 2020-250-САО-2/2-6.1.7.4.2

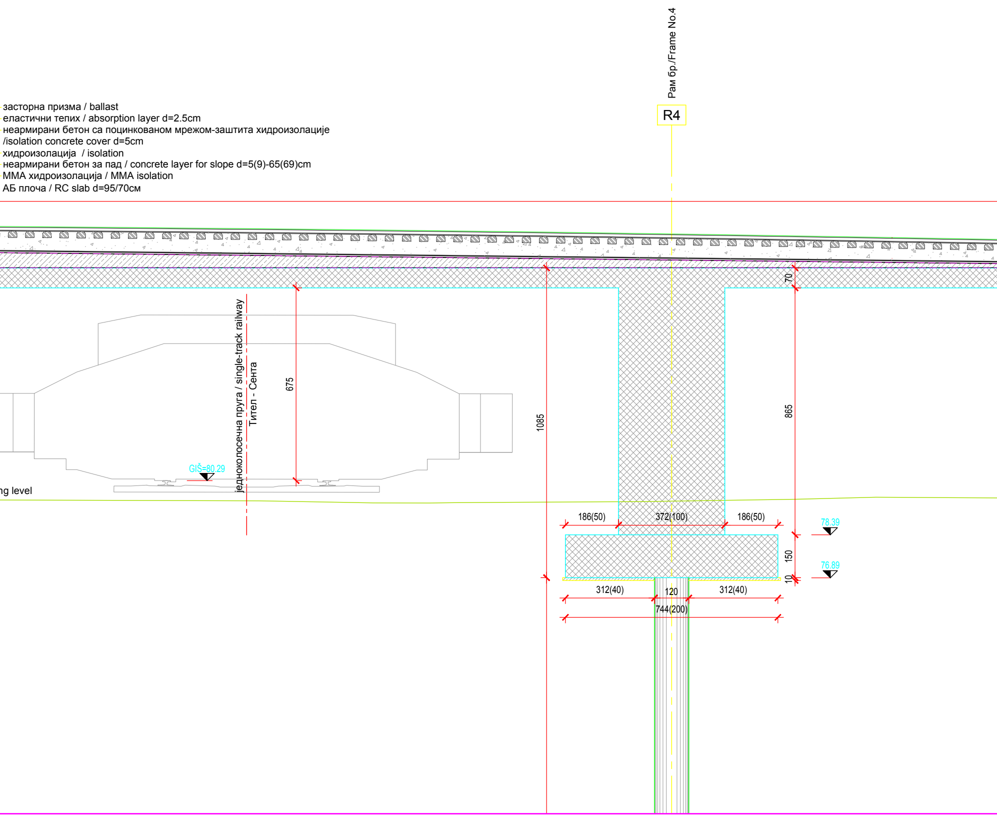

Нови
2500(min2000)
1500
II
1:1
1:1
постојећи терен / existing level
300

ПОДУЖНИ ПРЕСЕК ГАЛЕРИЈЕ НА КМ 78+
LONGITUDINAL SECTION OF GALLERY AT KM

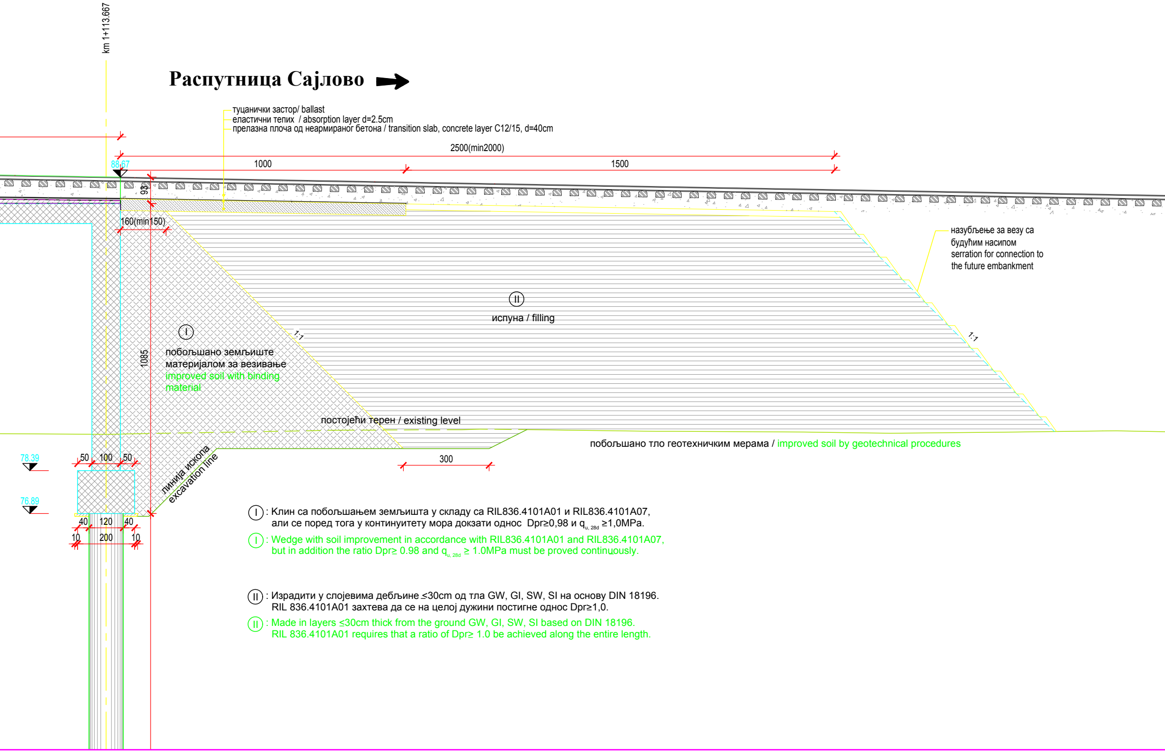
Сад Путничка


km 1+006.135
Рам бр./Frame No.2
R2
2
627
1000
88.89
88.99
115
160(min150)
95
95
87.74
86.79
988
①
1085
840
1085
840
650
леви колосек / left track
Нови Сад - Суботица
GIŠ=80.29
78.39
78.39
76.89
76.89
50
100
50
186(50)
372(100)
186(50)
150
10
150
10
линија ископа
excavation line
40
120
40
10
200
10
312(40)
120
312(40)
744(200)


401.27 Д.К. (78+377.03 Л.К.)
78+401.27 R.T. (78+377.03 L.T.)
km 1+053.520
km 1+059.901
1
Рам бр./Frame No.3
R3
средина галерије по прузи / the middle
of the gallery along the railway line
Нови Сад Путничка-Распутница Сајлово
10853
горња кота парапета / upper elevation of the parapet
max GIŠ = 89.27
GIŠ = 89.26
1.1%
1.1%
70
87.04
146(10)
146(10)
372(100)
десни колосек / right track
Нови Сад - Суботица
650
1085
865
GIŠ=80.29
постојећи терен / existi
332(60)
80
332(60)
78.39
150
76.89
10
312(40)
120
312(40)
744(200)


засторна призма / ballast
еластични тепих / absorption layer d=2.5cm
неармирани бетон са поцинкованом мрежом-заштита хидроизолације
/isolation concrete cover d=5cm
хидроизолација / isolation
неармирани бетон за пад / concrete layer for slope d=5(9)-65(69)cm
MMA хидроизолација / MMA isolation
АБ плоча / RC slab d=95/70см
Рам бр./Frame No.4
R4
једноколосечна пруга / single-track railway
Тител - Сента
675
GIŠ=80.29
ng level
1085
70
865
186(50)
372(100)
186(50)
78.39
150
76.89
10
312(40)
120
312(40)
744(200)

Распутница Сајлово


km 1+113.667
туцанички застор/ ballast
еластични тепих / absorption layer d=2.5cm
прелазна плоча од неармираног бетона / transition slab, concrete layer C12/15, d=40cm
2500(min2000)
1000
1500
88.67
93
160(min150)
назубљење за везу са
будућим насипом
serration for connection to
the future embankment
II
испуна / filling
1:1
1:1
I
побољшано земљиште
материјалом за везивање
improved soil with binding
material
1085
постојећи терен / existing level
побољшано тло геотехничким мерама / improved soil by geotechnical procedures
300
78.39
76.89
50
100
50
линија ископа
excavation line
40
120
40
10
200
10

Ⓘ : Клин са побољшањем земљишта у складу са RIL836.4101A01 и RIL836.4101A07, али се поред тога у континуитету мора доказати однос Dpr≥0,98 и $q_{u,\ 28d}$ ≥1,0MPa.

Ⓘ : Wedge with soil improvement in accordance with RIL836.4101A01 and RIL836.4101A07, but in addition the ratio Dpr≥ 0.98 and $q_{u,\ 28d}$ ≥ 1.0MPa must be proved continuously.

(II) : Израдити у слојевима дебљине ≤30cm од тла GW, GI, SW, SI на основу DIN 18196. RIL 836.4101A01 захтева да се на целој дужини постигне однос Dpr≥1,0.

(II) : Made in layers ≤30cm thick from the ground GW, GI, SW, SI based on DIN 18196. RIL 836.4101A01 requires that a ratio of Dpr≥ 1.0 be achieved along the entire length.

03		
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Број/Number	Датум / Date	Опис / Description

Ревизиони блок:

САОБРАЋАЈНИ ИНСТИТУТ ЦИП, д.о.о.
INSTITUTE OF TRANSPORTATION CIP ltd
Немањина 6; 11000 Београд; Србија
Тел: 011/3618-134; Факс: 011/3618-324; web site: www.sicip.co.rs

Организациона јединица:САОБРАЋАЈНИЦЕ/Organization unit:DEPARTMENT OF ROADS AND RAILWAYS

Одговорни пројектант :
Responsible designer:
Драгана Јокановић, дипл.инж.грађ.
лиценца број:/ license No.: 315 1404 03

Сарадници:

Унутрашња контрола: / Internal control:
Милан Јелкић, дипл. грађ. инж.

Главни пројектант: / Chief designer:
Др Љиљана Милић Марковић, дипл.грађ.инж.

Руководилац организационе јединице:
Manager of organization unit:
мр Новица Стевановић , дипл.инж.грађ.

Инвеститор пројекта:
" ИНФРАСТРУКТУРА ЖЕЛЕЗНИЦЕ СРБИЈЕ " А.Д.
/ " INFRASTRUCTURE RAILWAYS OF SERBIA " JSC
Немањина 6/IV, Београд **/ Nemanjina Street 6/IV, Belgrade**

Наручилац пројекта:
Joint Venture of
China Railway International Corporation Ltd. (CRIC)
No.10 Fuxing Road,Haidian District,Beijing
P.R China, 100844

China Communication Construction Company Ltd. (CCCC)
No.85 Deshengmenwai Street,Xicheng District,Beijing
P.R China, 100088

Објекат: /Structure:
ПРУГА БЕОГРАД - СУБОТИЦА - ДРЖАВНА ГРАНИЦА (КЕЛЕБИЈА)
ДЕОНИЦА ПРУГЕ НОВИ САД - СУБОТИЦА - ДРЖАВНА ГРАНИЦА (КЕЛЕБИЈА)

BELGRADE - SUBOTICA - STATE BORDER (KELEBIA) RAILWAY LINE
SECTION : NOVI SAD - SUBOTICA - STATE BORDER (KELEBIA)

Део пројекта: / Part of Design:
2/2.6.1 ПРОЈЕКАТ ГОРЊЕГ СТРОЈА ЗА МОСТОВСКЕ КОНСТРУКЦИЈЕ ДУЖИНЕ ПРЕКО 40м-ДЕОНИЦА НОВИ САД-РУМЕНКА ИЗЛАЗ

2/2.6.1 DESIGN OF SUPERSTRUCTURE FOR BRIDGE STRUCTURES LONGER THAN 40M SECTION NOVI SAD-RUMENKA ENTRY

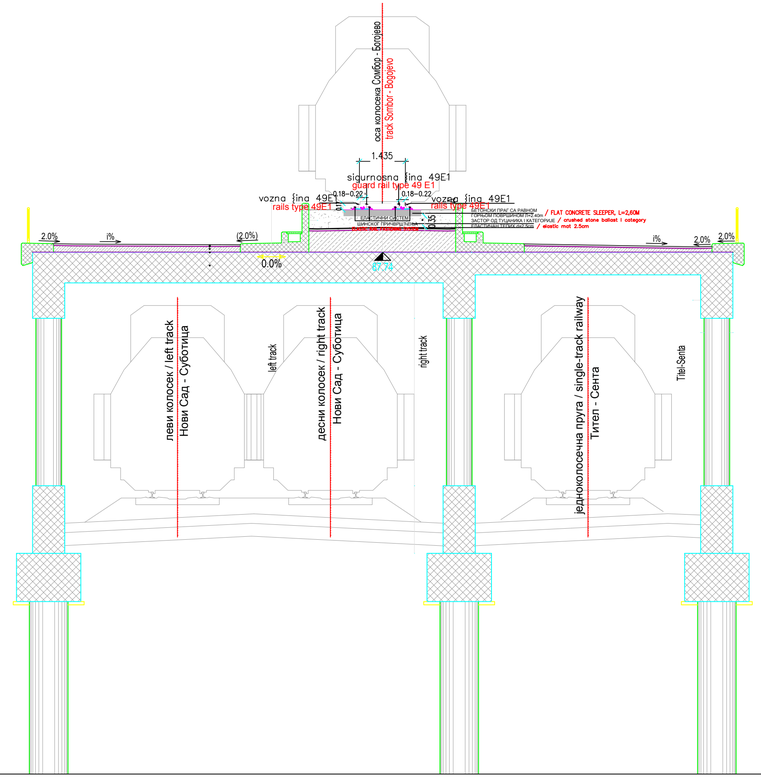
Цртеж: **ПОДУЖНИ ПРЕСЕК ГАЛЕРИЈЕ**
НА КМ 78+401.27Д.К. (78+377.03 Л.К.)

LONGITUDINAL PROFILE OF THE GALLERY
AT KM 78+401.27 R.T. (78+377.03 L.T.)

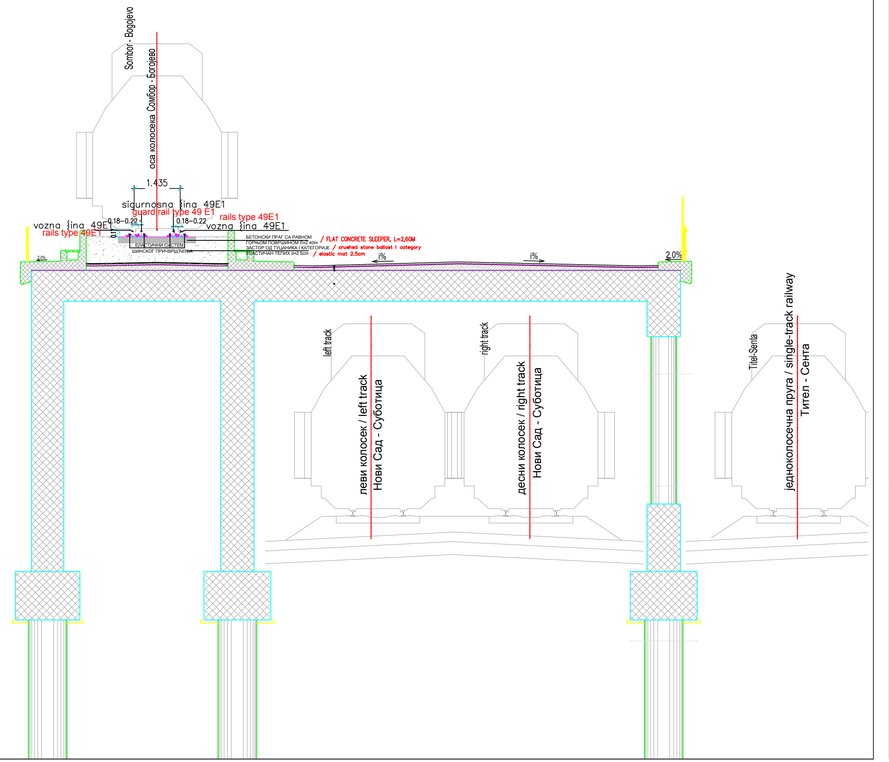
Размера: Scale: 1:200

Врста тех.док.: Type of tech.docum.:	датум:/date:	Цртеж бр./Drawing No.:
ПЗИ / DFC	**08.2021**	2020-250-CAO-2/2-6.1.7.5.1

ПОПРЕЧНИ ПРОФИЛ ГАЛЕРИЈЕ НА КМ 78+401.27 Д.К. (78+377.03 Л.К.)
CROSS SECTION OF THE GALLERY AT KM 78+401.27 R.T.(78+377.03 L.T.)



ПОПРЕЧНИ ПРОФИЛ ГАЛЕРИЈЕ НА КМ 78+401.27Д.К. (78+377.03 Л.К.)
CROSS SECTION OF THE GALLERY AT KM 78+401.27 R.T.(78+377.03 L.T.)



Број /Number	Датум / Date	Опис / Description
03		
02		
01		

Ревизиони блок:

САОБРАЋАЈНИ ИНСТИТУТ ЦИП, д.о.о.
INSTITUTE OF TRANSPORTATION CIP ltd
Немањина 6; 11000 Београд; Србија
Тел: 011/3618-134; Факс: 011/3618-324; web site: www.sicip.co.rs

Организациона јединица:САОБРАЋАЈНИЦЕ /Organization unit:DEPARTMENT OF ROADS AND RAILWAYS

Одговорни пројектант: / Responsible designer:
Драгана Јокановић, дипл.инж.грађ.
лиценца број: / license No.: 315 1404 03

Сарадници: / Associates:

Инвеститор пројекта:
" ИНФРАСТРУКТУРА ЖЕЛЕЗНИЦЕ СРБИЈЕ " А.Д.
" INFRASTRUCTURE RAILWAYS OF SERBIA " JSC
Немањина 6/IV, Београд / Nemanjina Street 6/IV, Belgrade

Научнилац пројекта: Joint Venture of
China Railway International Corporation Ltd. (CRIC)
No.10 Fuxing Road Haidian District,Beijing
P.R China, 100044
China Communication Construction Company Ltd. (CCCC)
No.85 Deshengmenwai Street,Xicheng District,Beijing
P.R China, 100088

Објекат: /Structure:
ПРУГА БЕОГРАД - СУБОТИЦА - ДРЖАВНА ГРАНИЦА (КЕЛЕБИЈА)
ДЕОНИЦА ПРУТЕ НОВИ САД - СУБОТИЦА - ДРЖАВНА ГРАНИЦА (КЕЛЕБИЈА)
BELGRADE - SUBOTICA - STATE BORDER (KELEBIA) RAILWAY LINE
SECTION : NOVI SAD - SUBOTICA - STATE BORDER (KELEBIA)

Део пројекта: / Part of Design:
2/2.6.1 ПРОЈЕКАТ ГОРЊЕГ СТРОЈА ЗА МОСТОВСКЕ КОНСТРУКЦИЈЕ ДУЖИНЕ ПРЕКО 40М-ДЕОНИЦА НОВИ САД-РУМЕНКА ИЗЛАЗ
2/2.6.1 DESIGN OF SUPERSTRUCTURE FOR BRIDGE STRUCTURES LONGER THAN 40M SECTION NOVI SAD-RUMENKA ENTRY

Унутрашња контрола: / Internal control:
Милан Јелкић, дипл.грађ.инж.

Главни пројектант:/ Chief designer:
Љиљана Милић Марковић, дипл.грађ.инж.

Руководилац организационе јединице:
Manager of organization unit:
мр Новица Стевановић , дипл.инж.грађ.

Цртеж: / Drawing:
ПОПРЕЧНИ ПРОФИЛ ГАЛЕРИЈЕ НА КМ 78+401.27Д.К. (78+377.03 Л.К.)
CROSS SECTION OF THE GALLERY AT KM 78+401.27 R.T. (78+377.03 L.T.)

Размера: Scale: 1:100

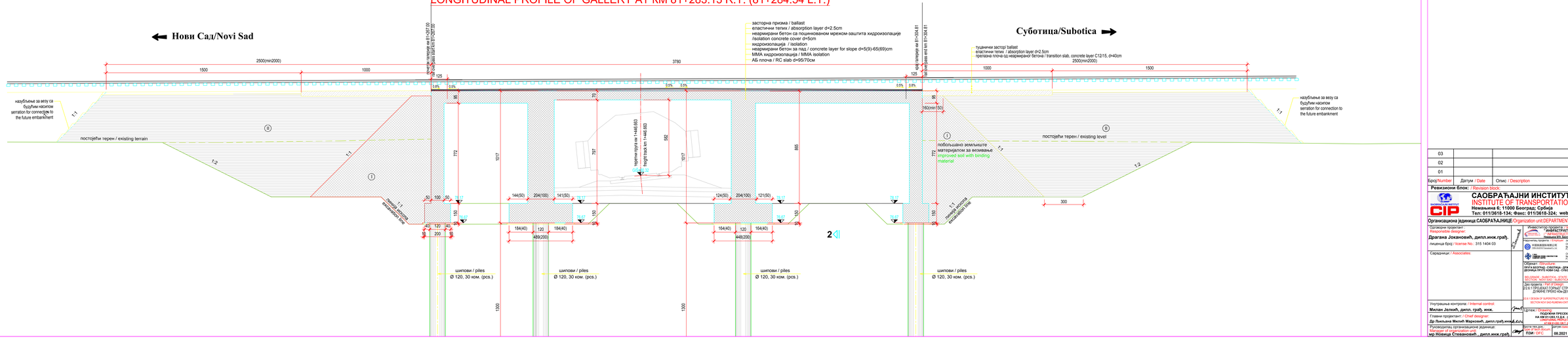
Врста тех.док.: Type of tech.docum: **ПЗИ** / DFC

датум:/date: **08.2021.**

Цртеж бр. /Drawing No.: 2020-250-CAO-2/2-6.1.7.5.2.

ПОДУЖНИ ПРЕСЕК ГАЛЕРИЈЕ НА КМ 81+283.13 Д.К. (81+284.54Л.К.)

LONGITUDINAL PROFILE OF GALLERY AT KM 81+283.13 R.T. (81+284.54 L.T.)



03		
02		
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Број/Number	Датум / Date	Опис / Description

Ревизиони блок: / Revision block

САОБРАЋАЈНИ ИНСТИТУТ ЦИП, д.о.о.
INSTITUTE OF TRANSPORTATION CIP ltd
Немањина 6; 11000 Београд; Србија
Тел: 011/3618-134; Факс: 011/3618-324; web site: www.sicip.cs.rs
Организациона јединица:САОБРАЋАЈНИЦЕ Organization unit:DEPARTMENT OF ROADS AND RAILWAYS
Одговорни пројектант / Responsible designer:
Драгана Јокановић, дипл.инж.грађ.
лиценца број / license No.: 315 1404 03
Сарадници / Associates:

Инвеститор пројекта / Investor:
ИНФРАСТРУКТУРА ЖЕЛЕЗНИЦЕ СРБИЈЕ "А.Д. НОВИ САД" / RAILWAYS OF SERBIA - JSC NOVI SAD
Немањина 6, 11000 Београд, Србија / Nemanjina 6, 11000 Belgrade, Serbia

Извођач радова / Contractor:
China Railway International Corporation Ltd. (CRIC)
China Communication Construction Company Ltd (CCCC)
Joint venture P...

Пројектанти / Designers:
China Railway International Co.,Ltd. (CRIC)
China Railway Design Corporation (CRDC)
P.R.China, 100044

China Communication Construction Company Ltd. (CCCC)
Highway Consultants Co., Ltd.
P.R.China, 100088

Објекат / Project:
ПРУГА БЕОГРАД - СУБОТИЦА - ДРЖАВНА ГРАНИЦА /ЖЕЛЕЗНА/
ДЕОНИЦА ПРУГЕ НОВИ САД - СУБОТИЦА - ДРЖАВНА ГРАНИЦА /ЖЕЛЕЗНА/

BELGRADE - SUBOTICA - STATE BORDER (RAILWAY) LINE
SECTION: NOVI SAD - SUBOTICA - STATE BORDER (RAILWAY)

Део пројекта / Part of Design:
22.6.1 ПРОЈЕКАТ ГОРЊЕГ СТРОЈА ЗА МОСТОВСКЕ КОНСТРУКЦИЈЕ ДУЖИНЕ ПРЕКО 10м ДЕОНИЦА НОВИ САД-РУМЕНКА /OR83

22.6.1 DESIGN OF SUPERSTRUCTURE FOR BRIDGE STRUCTURES LONGER THAN 10M SECTION NOVI SAD-RUMENKA (OR83)

Унутрашња контрола / Internal control:
Милан Јелкић, дипл. грађ. инж.

Главни пројектант / Chief designer:
Др Љиљана Милић Марковић, дипл.грађ.инж.

Руководилац организационе јединице:
Manager of organization unit:
мр Новица Стевановић , дипл.инж.грађ.

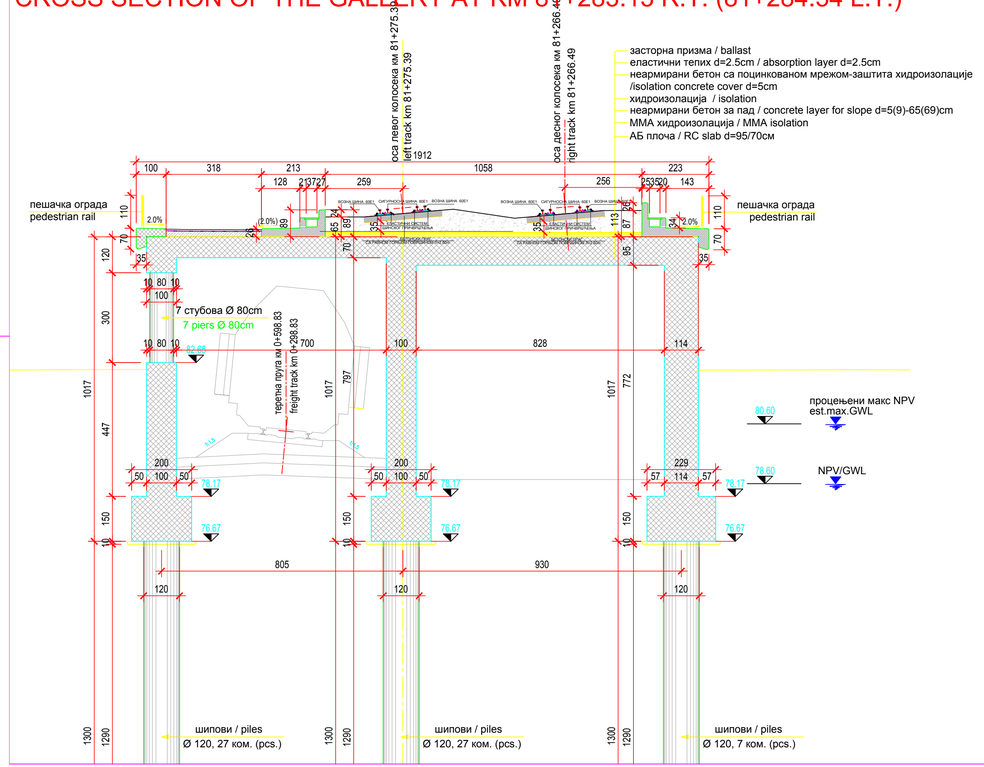
Цртеж / Drawing: ПОДУЖНИ ПРЕСЕК ГАЛЕРИЈЕ НА КМ 81+283.13 Д.К. (81+284.54 Л.К.)
LONGITUDINAL PROFILE OF GALLERY AT KM 81+283.13 R.T. (81+284.54 L.T.)

Размера / Scale: 1:200

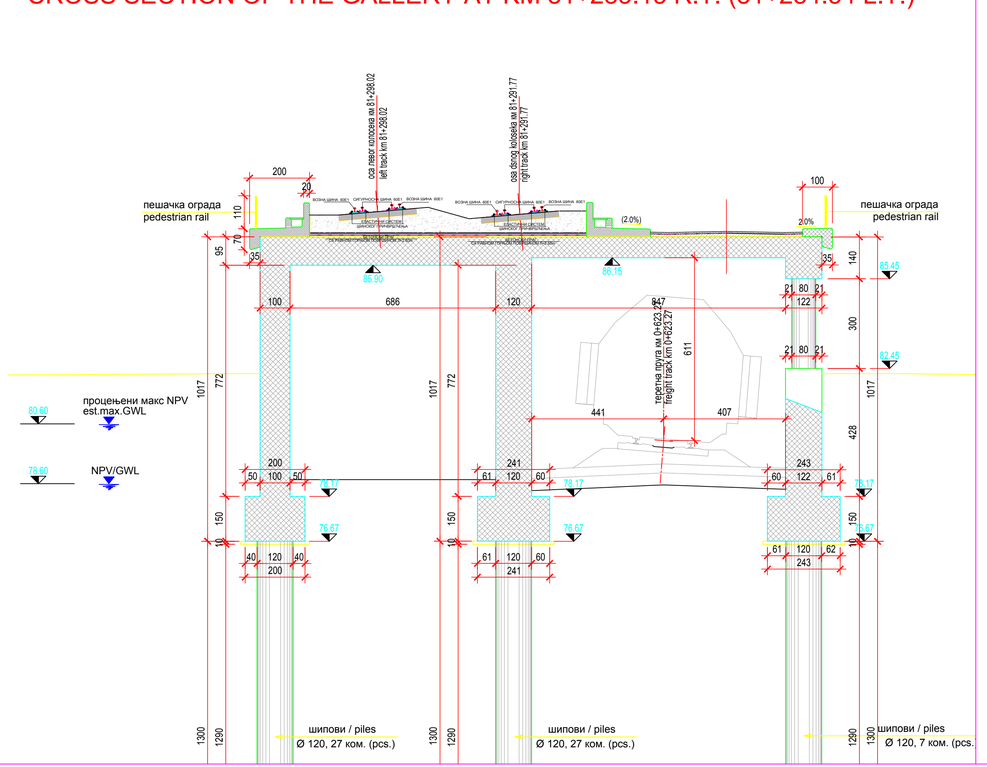
Датум израде / Date: 08.2021

Цртеж бр. / Drawing No.: 2020-200-DAO-22-6.1.7.6.1.

ПОПРЕЧНИ ПРЕСЕК ГАЛЕРИЈЕ НА КМ 81+283.13 Д.К. (81+284.54ЛЛ.К.)
CROSS SECTION OF THE GALLERY AT KM 81+283.13 R.T. (81+284.54 L.T.)



ПОПРЕЧНИ ПРЕСЕК ГАЛЕРИЈЕ НА КМ 81+283.13 Д.К. (81+284.54 Л.К.)
CROSS SECTION OF THE GALLERY AT KM 81+283.13 R.T. (81+284.54 L.T.)



03		
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Број /Number	Датум / Date	Опис / Description

Ревизиони блок:

САОБРАЋАЈНИ ИНСТИТУТ ЦИП, д.о.о.
INSTITUTE OF TRANSPORTATION CIP ltd
Немањина 6; 11000 Београд; Србија
Тел: 011/3618-134; Факс: 011/3618-324; web site: www.sicip.co.rs

Организациона јединица:САОБРАЋАЈНИЦЕ /Organization unit:DEPARTMENT OF ROADS AND RAILWAYS

Одговорни пројектант :
Responsible designer:
Драгана Јокановић, дипл.инж.грађ.
лиценца број: / license No.: 315 1404 03

Сарадници: / Associates:

Инвеститор пројекта:
" ИНФРАСТРУКТУРА ЖЕЛЕЗНИЦЕ СРБИЈЕ " А.Д.
" INFRASTRUCTURE RAILWAYS OF SERBIA " JSC
Немањина 6/IV, Београд / Nemanjina Street 6/IV, Belgrade

Извођач пројекта:
Joint Venture of
China Railway International Corporation Ltd. (CRIC)
No.12 Fuxing Road,Haidian District,Beijing
P.R.China, 100844
China Communication Construction Company Ltd. (CCCC)
No.85 Deshengmenwai Street,Xicheng District,Beijing
P.R.China, 100088

Објекат: /Structure:
ПРУГА БЕОГРАД - СУБОТИЦА - ДРЖАВНА ГРАНИЦА (КЕЛЕБИЈА)
ДЕОНИЦА ПРУГЕ НОВИ САД - СУБОТИЦА - ДРЖАВНА ГРАНИЦА (КЕЛЕБИЈА)
BELGRADE - SUBOTICA - STATE BORDER (KELEBIJA) RAILWAY LINE
SECTION : NOVI SAD - SUBOTICA - STATE BORDER (KELEBIJA)

Део пројекта: / Part of Design:
2/2.6.1 ПРОЈЕКАТ ГОРЊЕГ СТРОЈА ЗА МОСТОВСКЕ КОНСТРУКЦИЈЕ ДУЖИНЕ ПРЕКО 40М-ДЕОНИЦА НОВИ САД-РУМЕНКА УЛАЗ
2/2.6.1 DESIGN OF SUPERSTRUCTURE FOR BRIDGE STRUCTURES LONGER THAN 40M SECTION NOVI SAD-RUMENKA ENTRY

Унутрашња контрола: / Internal control:
Милан Јелкић, дипл.грађ.инж.

Главни пројектант: / Chief designer:
Др Љиљана Милић Марковић, дипл.грађ.инж.

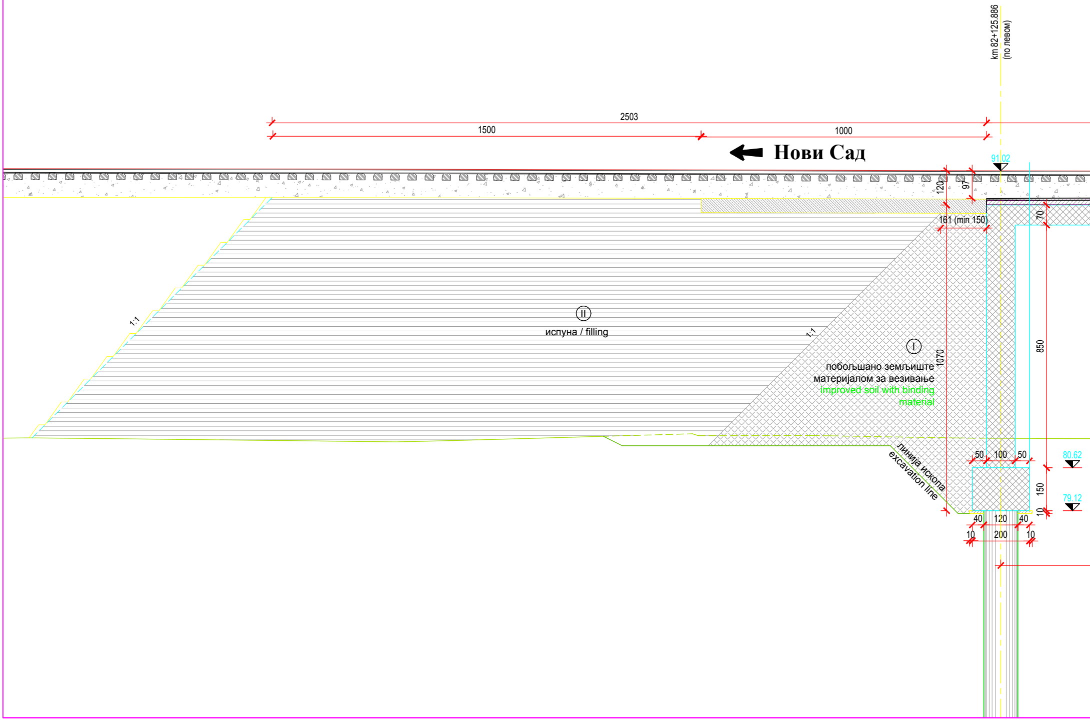
Руководилац организационе јединице:
Manager of organization unit:
мр Новица Стевановић , дипл.инж.грађ.

Цртеж: / Drawing:

ПОПРЕЧНИ ПРОФИЛ ГАЛЕРИЈЕ НА КМ 81+283.13 Д.К. (81+284.54 Л.К.)
CROSS SECTION OF THE GALLERY AT KM 81+283.13 R.T. (81+284.54 L.T.)

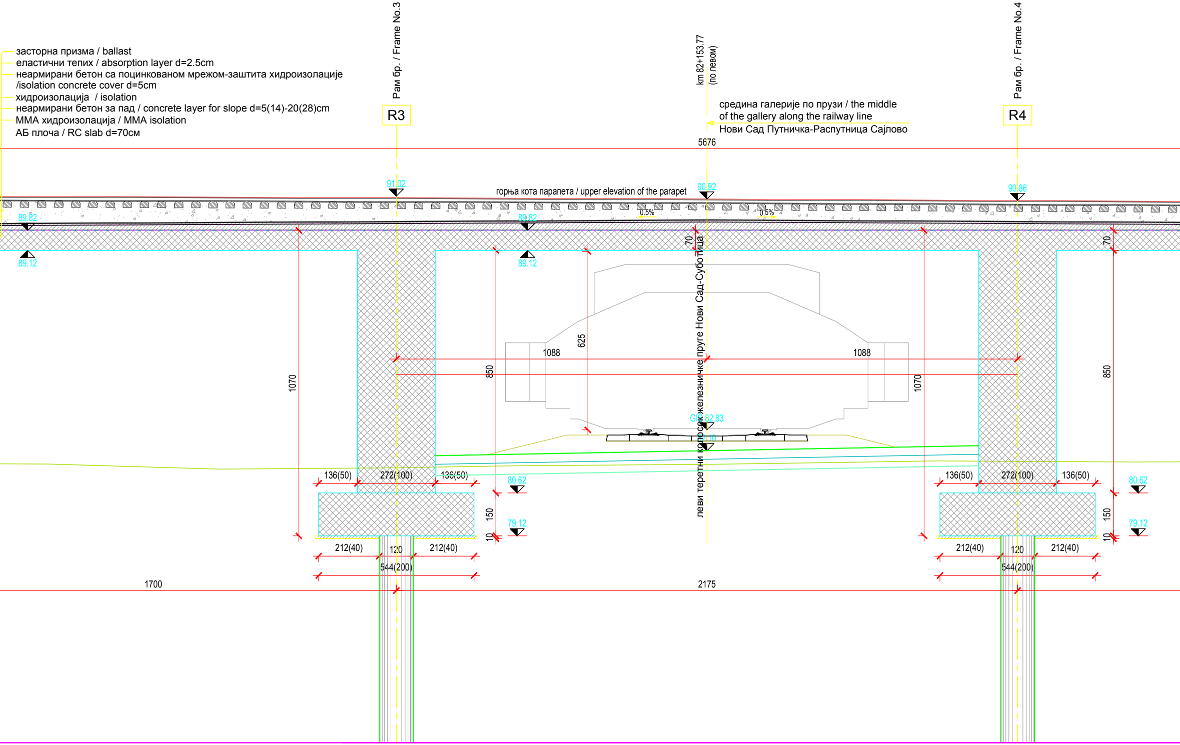
Размера: Scale: 1:50

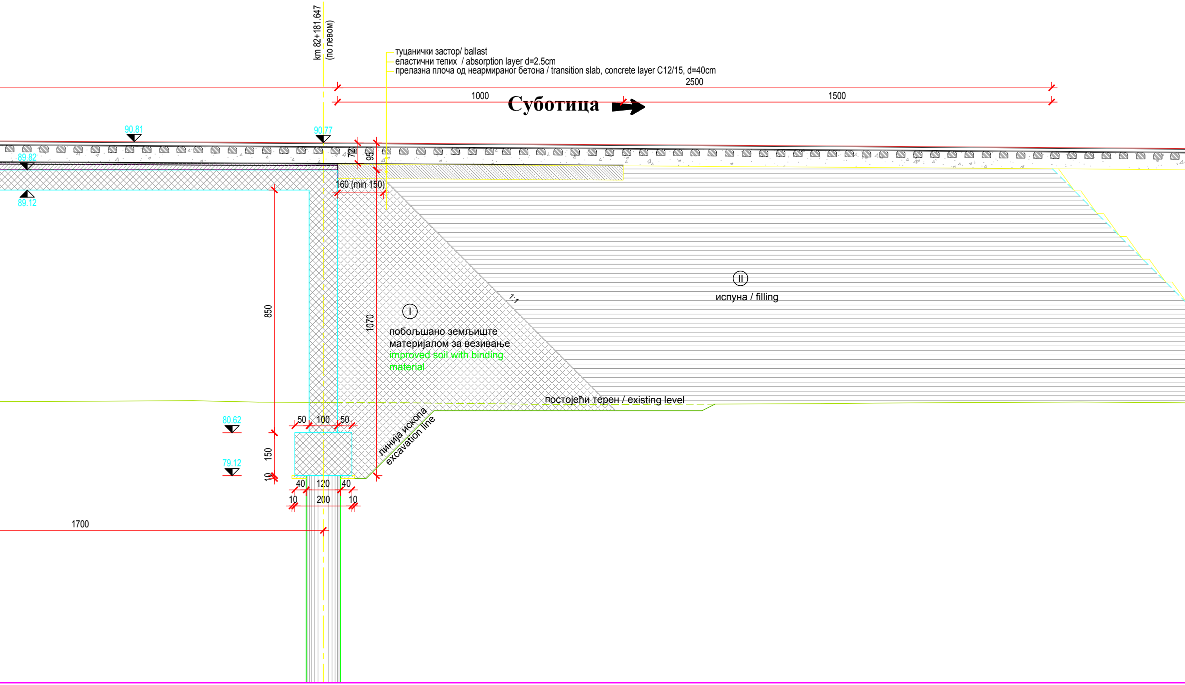
Врста тех.док.: / Type of tech.docum.	Датум: /Date	Цртеж бр. /Drawing No.:
ПЗИ / DFC	08.2021.	2020-250-САО-2/2-6.1.7.6.2.

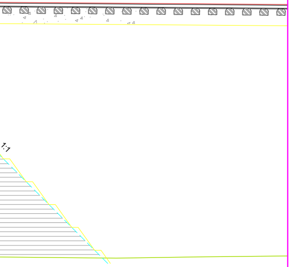

km 82+125.886
(по левом)
2503
1500
1000
Нови Сад
91.02
120
97
70
161 (min 150)
1:1
II
испуна / filling
1:1
I
побољшано земљиште
материјалом за везивање
improved soil with binding
material
1070
850
линија ископа
excavation line
50
100
50
80.62
150
79.12
10
40
120
40
10
200
10

ПОДУЖНИ ПРЕСЕК ГАЛЕРИЈЕ НА КМ 82+152.69 Д.К. (82+153.77 Л.К.)

LONGITUDINAL PROFILE OF GALLERY AT КМ 82+152.69 R.T. (82+153.77 L.T.)


засторна призма / ballast
еластични тепих / absorption layer d=2.5cm
неармирани бетон са поцинкованом мрежом-заштита хидроизолације
/isolation concrete cover d=5cm
хидроизолација / isolation
неармирани бетон за пад / concrete layer for slope d=5(14)-20(28)cm
MMA хидроизолација / MMA isolation
АБ плоча / RC slab d=70см
Рам бр. / Frame No.3
R3
km 82+153.77
(по левом)
средина галерије по прузи / the middle
of the gallery along the railway line
Нови Сад Путничка-Распутница Сајлово
Рам бр. / Frame No.4
R4
5676
91.02
горња кота парапета / upper elevation of the parapet
90.92
90.86
89.82
89.82
0.5%
0.5%
89.12
89.12
70
70
левi теретни колосек железничке пруге Нови Сад-Суботица
625
1088
1088
850
1070
1070
850
GK 82.83
82.10
136(50)
272(100)
136(50)
80.62
136(50)
272(100)
136(50)
80.62
150
79.12
150
79.12
10
10
212(40)
120
212(40)
544(200)
212(40)
120
212(40)
544(200)
1700
2175


km 82+181.647
(по левом)
туцанички застор/ ballast
еластични тепих / absorption layer d=2.5cm
прелазна плоча од неармираног бетона / transition slab, concrete layer C12/15, d=40cm
2500
1000
1500
Суботица
90.81
90.77
89.82
89.12
72
95
160 (min 150)
850
1070
1:1
II
испуна / filling
I
побољшано земљиште
материјалом за везивање
improved soil with binding
material
постојећи терен / existing level
линија ископа
excavation line
80.62
79.12
50
100
50
150
10
40
120
40
10
200
10
1700



03		
02		
01		
Број /Number	Датум / Date	Опис / Description

Ревизиони блок: / Revision block:

САОБРАЋАЈНИ ИНСТИТУТ ЦИП, д.о.о.
INSTITUTE OF TRANSPORTATION CIP ltd

Немањина 6; 11000 Београд; Србија
Тел: 011/3618-134; Факс: 011/3618-324; web site: www.sicip.co.rs

Организациона јединица:САОБРАЋАЈНИЦЕ /Organization unit:DEPARTMENT OF ROADS AND RAILWAYS

Одговорни пројектант : Responsible designer:
Драгана Јокановић, дипл.инж.грађ.
лиценца број: / license No.: 315 1404 03

Сарадници: / Associates:

Унутрашња контрола: / Internal control:
Милан Јелкић, дипл. грађ. инж.

Главни пројектант: / Chief designer:
Др Љиљана Милић Марковић, дипл.грађ.инж.

Руководилац организационе јединице:
Manager of organization unit:
мр Новица Стевановић , дипл.инж.грађ.

Инвеститор пројекта:
" ИНФРАСТРУКТУРА ЖЕЛЕЗНИЦЕ СРБИЈЕ " А.Д.
/ " INFRASTRUCTURE RAILWAYS OF SERBIA " JSC
Немањина 6/IV, Београд / Nemanjina Street 6/IV, Belgrade

Наручилац пројекта:
Joint Venture of
China Railway International Corporation Ltd. (CRIC)
No.10 Fuxing Road,Haidian District,Beijing
P.R China, 100844

China Communication Construction Company Ltd. (CCCC)
No.85 Deshengmenwai Street,Xicheng District,Beijing
P.R China, 100088

Објекат: /Structure:
ПРУГА БЕОГРАД - СУБОТИЦА - ДРЖАВНА ГРАНИЦА (КЕЛЕБИЈА)
ДЕОНИЦА ПРУГЕ НОВИ САД - СУБОТИЦА - ДРЖАВНА ГРАНИЦА (КЕЛЕБИЈА)

BELGRADE - SUBOTICA - STATE BORDER (KELEBIA) RAILWAY LINE
SECTION : NOVI SAD - SUBOTICA - STATE BORDER (KELEBIA)

Део пројекта: / Part of Design:
2/2.6.1 ПРОЈЕКАТ ГОРЊЕГ СТРОЈА ЗА МОСТОВСКЕ КОНСТРУКЦИЈЕ ДУЖИНЕ ПРЕКО 40м-ДЕОНИЦА НОВИ САД-РУМЕНКА ИЗЛАЗ

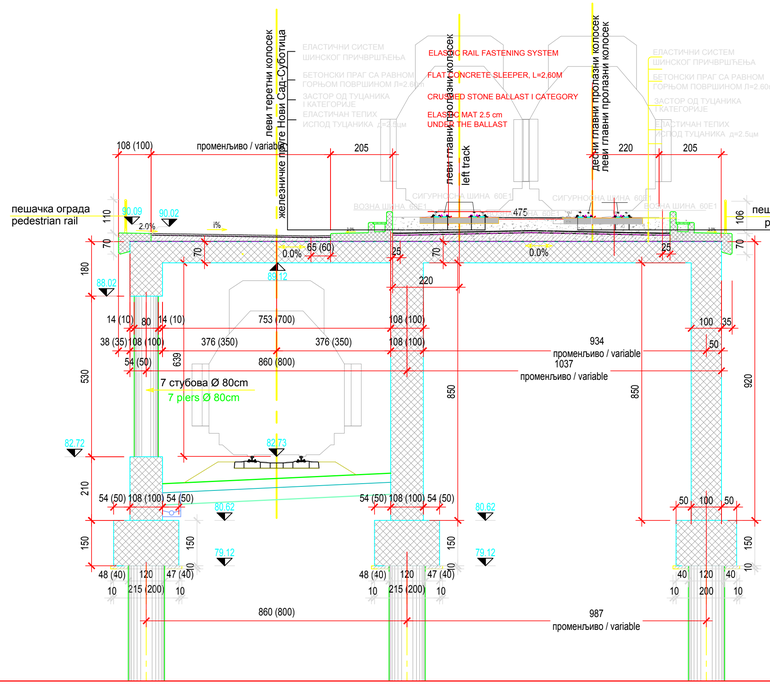
2/2.6.1 DESIGN OF SUPERSTRUCTURE FOR BRIDGE STRUCTURES LONGER THAN 40M SECTION NOVI SAD-RUMENKA ENTRY

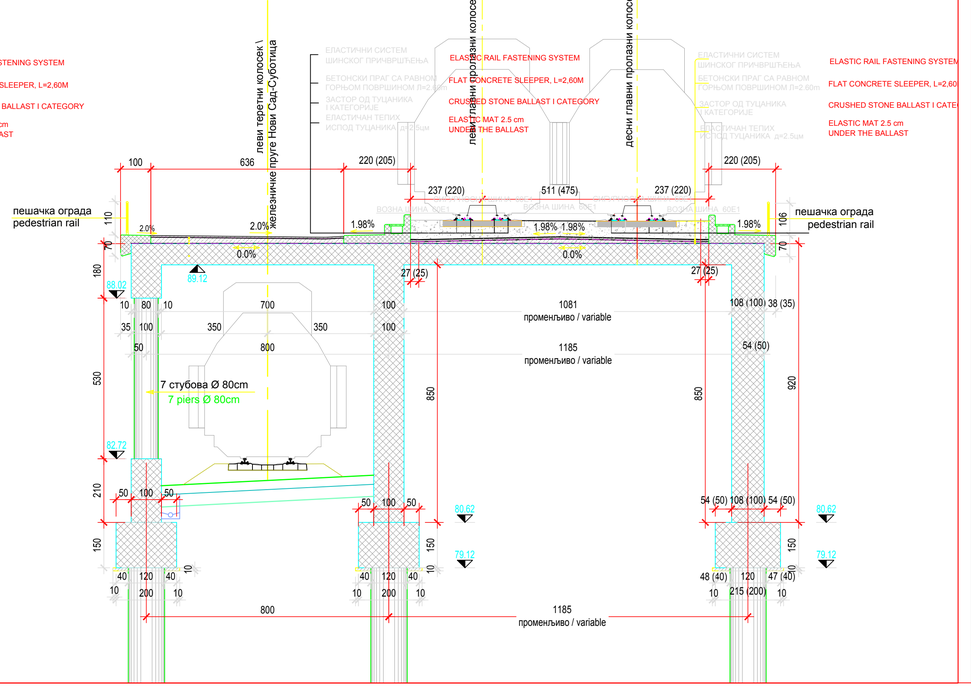
Цртеж: / Drawing: **ПОДУЖНИ ПРЕСЕК ГАЛЕРИЈЕ НА КМ 82+152.69 Д.К. (82+153,77 Л.К.)**
LONGITUDINAL PROFILE OF THE GALLERY AT KM 82+152.69R.T. (82+153.77 L.T.)

Размера: Scale: 1:200

Врста тех.док.: Type of tech.docum.:	датум:/date:	Цртеж бр. /Drawing No.:
ПЗИ / DFC	**08.2021**	2020-250-CAO-2/2-6.1.7.7.1

ПОПРЕЧНИ ПРОФИЛ ГАЛЕРИЈЕ НА КМ 82+152.69 Д.К. (82+153.77 Л.К.)
CROSS SECTION OF THE GALLERY AT KM 82+152.69 R.T.(82+153.77 L.T.)





Број /Number	Датум / Date	Опис / Description
03		
02		
01		

Ревизиони блок:

САОБРАЋАЈНИ ИНСТИТУТ ЦИП, д.о.о.
INSTITUTE OF TRANSPORTATION CIP ltd
Немањина 6; 11000 Београд; Србија
Тел: 011/3618-134; Факс: 011/3618-324; web site: www.sicip.co.rs

Организациона јединица:САОБРАЋАЈНИЦЕ /Organization unit:DEPARTMENT OF ROADS AND RAILWAYS

Одговорни пројектант : / Responsible designer:
Драгана Јокановић, дипл.инж.грађ.
лиценца број: / license No.: 315 1404 03

Инвеститор пројекта: / Investitor:
ИНФРАСТРУКТУРА ЖЕЛЕЗНИЦЕ СРБИЈЕ " А.Д. / INFRASTRUCTURE RAILWAYS OF SERBIA" JSC
Немањина 6/IV, Београд / Nemanjina Street 6/IV, Belgrade

Научилац пројекта: Joint Venture of
China Railway International Corporation Ltd. (CRIC) No.10 Fuxing Road Haidian District,Beijing P.R.China, 700048
China Communication Construction Company Ltd. (CCCC) No.85 Deshengmenwai Street,Xicheng District,Beijing P.R.China, 100088

Сарадници: / Associates:

Објекат: /Structure:
ПРУГА БЕОГРАД - СУБОТИЦА - ДРЖАВНА ГРАНИЦА (КЕЛЕБИЈА)
ДЕОНИЦА ПРУТЕ НОВИ САД - СУБОТИЦА - ДРЖАВНА ГРАНИЦА (КЕЛЕБИЈА)
BELGRADE - SUBOTICA - STATE BORDER (KELEBIA) RAILWAY LINE
SECTION : NOVI SAD - SUBOTICA - STATE BORDER (KELEBIA)

Део пројекта: / Part of Design:
2/2.6.1 ПРОЈЕКАТ ГОРЊЕГ СТРОЈА ЗА МОСТОВСКЕ КОНСТРУКЦИЈЕ ДУЖИНЕ ПРЕКО 40М,ДЕОНИЦА НОВИ САД-РУМЕНКА УЛАЗ
2/2.6.1 DESIGN OF SUPERSTRUCTURE FOR BRIDGE STRUCTURES LONGER THAN 40M SECTION:NOVI SAD-RUMENKA ENTRY

Унутрашња контрола: / Internal control:

Главни пројектант:/ Chief designer:
Др Љиљана Милић Марковић, дипл.грађ.инж.

Руководилац организационе јединице: / Manager of organization unit:
мр Новица Стевановић , дипл.инж.грађ.

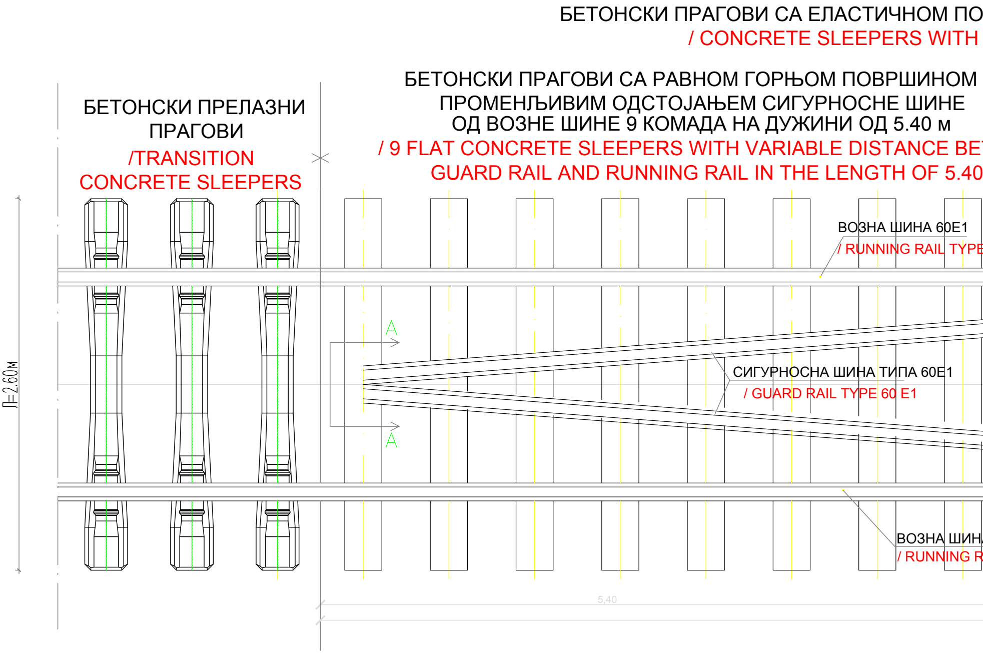
Цртеж: / Drawing:
ПОПРЕЧНИ ПРОФИЛ ГАЛЕРИЈЕ НА КМ 82+152.69 Д.К. (82+153.77 Л.К.)
CROSS SECTION OF THE GALLERY AT KM 82+152.69 R.T. (82+153.77 L.T.)

Размера: / Scale: 1:50

Врста тех.док: / Type of tech.docum.: **ПЗИ / DFC**

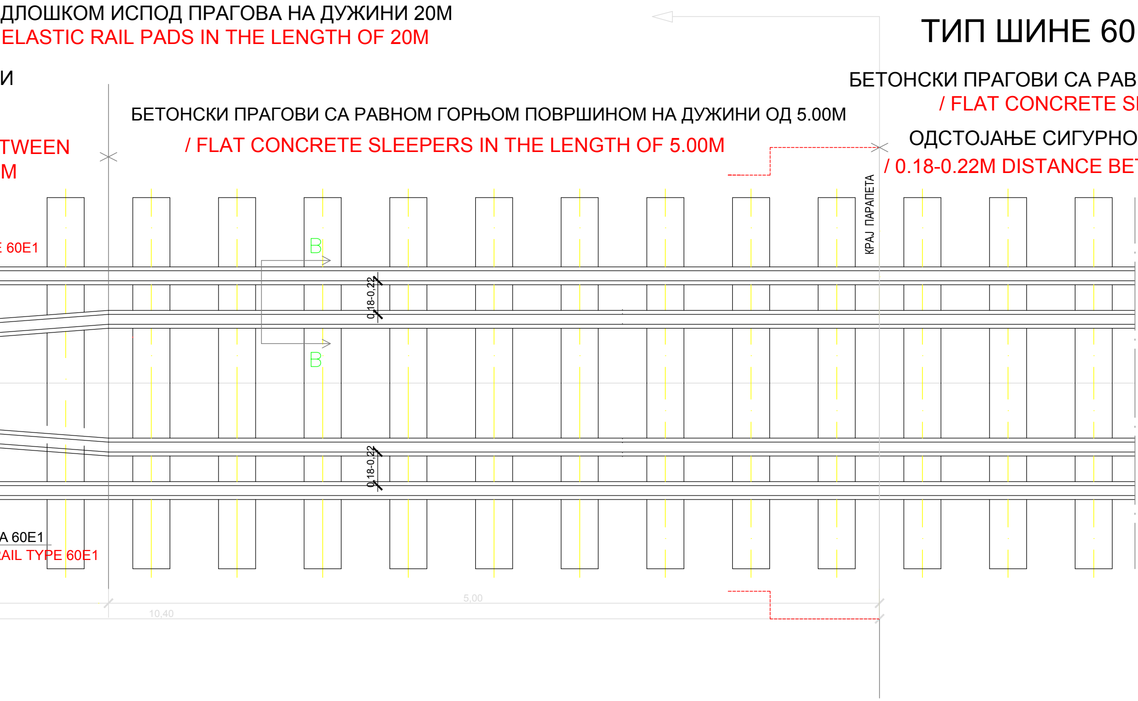
Датум /date: **08.2021.**

Цртеж бр. /Drawing No.: 2020-250-CAO-2/2-6.1.7.7.2.


БЕТОНСКИ ПРАГОВИ СА ЕЛАСТИЧНОМ ПО
/ CONCRETE SLEEPERS WITH
БЕТОНСКИ ПРАГОВИ СА РАВНОМ ГОРЊОМ ПОВРШИНОМ
ПРОМЕНЉИВИМ ОДСТОЈАЊЕМ СИГУРНОСНЕ ШИНЕ
ОД ВОЗНЕ ШИНЕ 9 КОМАДА НА ДУЖИНИ ОД 5.40 м
/ 9 FLAT CONCRETE SLEEPERS WITH VARIABLE DISTANCE BE
GUARD RAIL AND RUNNING RAIL IN THE LENGTH OF 5.40
БЕТОНСКИ ПРЕЛАЗНИ ПРАГОВИ
/TRANSITION CONCRETE SLEEPERS
Л=2.60м
ВОЗНА ШИНА 60Е1
/ RUNNING RAIL TYPE
A
A
СИГУРНОСНА ШИНА ТИПА 60Е1
/ GUARD RAIL TYPE 60 E1
ВОЗНА ШИН
/ RUNNING R
5,40

ДИСПОЗИЦИЈА КОЛОСЕКА НА М

ТИП ШИНЕ 60


ДЛОШКОМ ИСПОД ПРАГОВА НА ДУЖИНИ 20М
ELASTIC RAIL PADS IN THE LENGTH OF 20M
И
TWEEN
M
БЕТОНСКИ ПРАГОВИ СА РАВНОМ ГОРЊОМ ПОВРШИНОМ НА ДУЖИНИ ОД 5.00М
/ FLAT CONCRETE SLEEPERS IN THE LENGTH OF 5.00M
БЕТОНСКИ ПРАГОВИ СА РАВ
/ FLAT CONCRETE S
ОДСТОЈАЊЕ СИГУРНО
/ 0.18-0.22M DISTANCE BET
КРАЈ ПАРАПЕТА
E 60E1
B
B
0,18-0,22
0,18-0,22
A 60E1
RAIL TYPE 60E1
5,00
10,40

ЮСТОВИМА СА СИГУРНОСНОМ ШИНОМ / LAYOUT OF TRACKS W

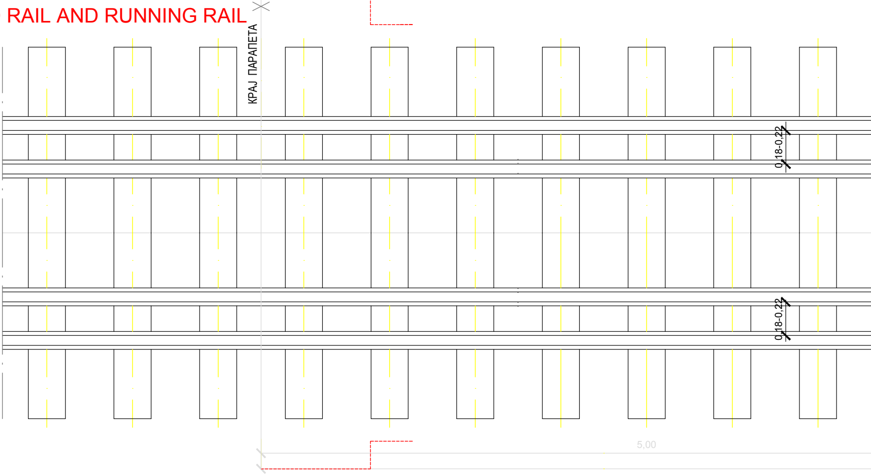
E1 / RAILS TYPE 60E1

НОМ ГОРЊОМ ПОВРШИНОМ У ЗОНИ МОСТА
LEEPERS IN THE BRIDGE AREA

СНЕ ШИНЕ ОД ВОЗНЕ ШИНЕ 0.18-0,22 м
TWEEN GUARD RAIL AND RUNNING RAIL

БЕТОНСКИ ПРАГОВИ СА ЕЛАСТ
/ CONCRETE SLEEPE

БЕТОНСКИ ПРАГОВИ СА РАВНОМ ГОРЊОМ ПОВРШИНО
/ FLAT CONCRETE SLEEPERS IN THE LENGTH


КРАЈ ПАРАПЕТА
0,18-0,22
0,18-0,22
5,00

VITH GUARD RAILS ON BRIDGES

ИЧНОМ ПОДЛОШКОМ ИСПОД ПРАГОВА НА ДУЖИНИ 20М

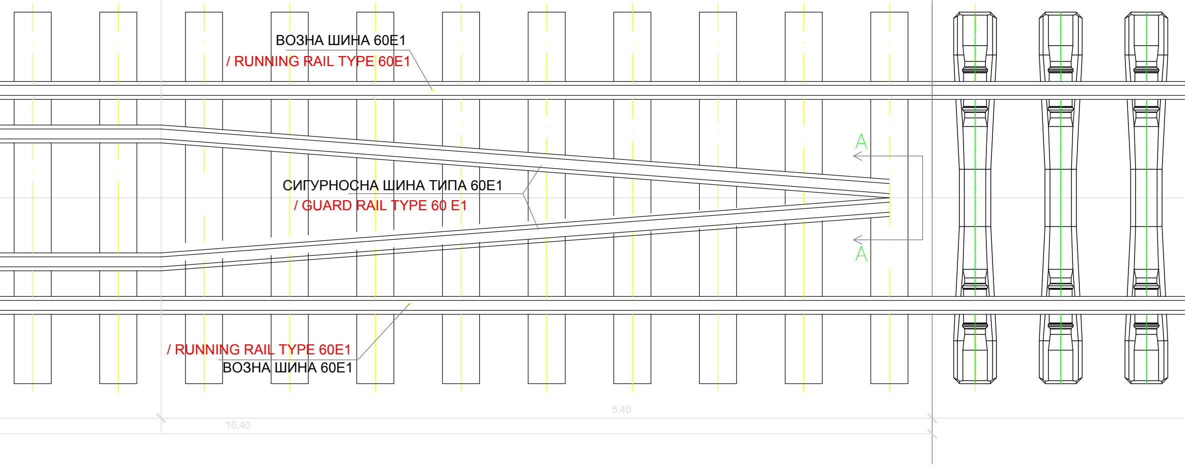
RS WITH ELASTIC RAIL PADS IN THE LENGTH OF 20M

М НА ДУЖИНИ ОД 5.00М

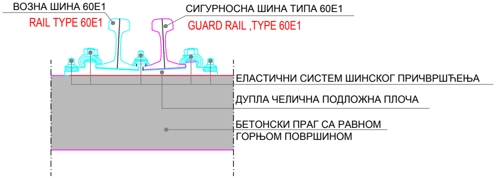
OF 5.00M

БЕТОНСКИ ПРАГОВИ СА РАВНОМ ГОРЊОМ ПОВРШИНОМ И
ПРОМЕНЉИВИМ ОДСТОЈАЊЕМ СИГУРНОСНЕ ШИНЕ
ОД ВОЗНЕ ШИНЕ 9 КОМАДА НА ДУЖИНИ ОД 5.40 м
/ 9 FLAT CONCRETE SLEEPERS WITH VARIABLE DISTANCE BETWEEN
GUARD RAIL AND RUNNING RAIL IN THE LENGTH OF 5.40M

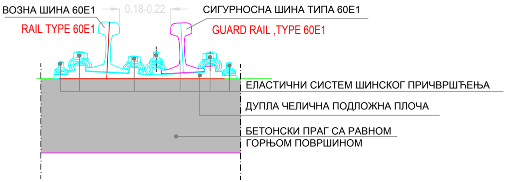
БЕТОНСКИ ПРЕЛАЗНИ
ПРАГОВИ
/TRANSITION
CONCRETE SLEEPERS


ВОЗНА ШИНА 60Е1
/ RUNNING RAIL TYPE 60E1
СИГУРНОСНА ШИНА ТИПА 60Е1
/ GUARD RAIL TYPE 60 E1
A
A
/ RUNNING RAIL TYPE 60E1
ВОЗНА ШИНА 60Е1
5,40
10,40

A-A
P=1:10


ВОЗНА ШИНА 60Е1
RAIL TYPE 60E1
СИГУРНОСНА ШИНА ТИПА 60Е1
GUARD RAIL ,TYPE 60E1
ЕЛАСТИЧНИ СИСТЕМ ШИНСКОГ ПРИЧВРШЋЕЊА
ДУПЛА ЧЕЛИЧНА ПОДЛОЖНА ПЛОЧА
БЕТОНСКИ ПРАГ СА РАВНОМ
ГОРЊОМ ПОВРШИНОМ

B-B
P=1:10


ВОЗНА ШИНА 60Е1
RAIL TYPE 60E1
0.18-0.22
СИГУРНОСНА ШИНА ТИПА 60Е1
GUARD RAIL ,TYPE 60E1
ЕЛАСТИЧНИ СИСТЕМ ШИНСКОГ ПРИЧВРШЋЕЊА
ДУПЛА ЧЕЛИЧНА ПОДЛОЖНА ПЛОЧА
БЕТОНСКИ ПРАГ СА РАВНОМ
ГОРЊОМ ПОВРШИНОМ

03		
02		
01		
Број/Number	Датум / Date	Опис / Description

Ревизиони блок: / Revision block:

САОБРАЋАЈНИ ИНСТИТУТ ЦИП, д.о.о.
INSTITUTE OF TRANSPORTATION CIP ltd
Немањина 6; 11000 Београд; Србија
Тел: 011/3618-134; Факс: 011/3618-324; web site: www.sicip.co.rs

Организациона јединица:САОБРАЋАЈНИЦЕ/Organization unit:DEPARTMENT OF ROADS AND RAILWAYS

Одговорни пројектант :
Responsible designer:
Драгана Јокановић, дипл.инж.грађ.
лиценца број:/ license No.: 315 1404 03

Сарадници: / Associates:

Унутрашња контрола: / Internal control:
Милан Јелкић, дипл. грађ. инж.

Главни пројектант: / Chief designer:
Др Љиљана Милић Марковић, дипл.грађ.инж.

Руководилац организационе јединице:
Manager of organization unit:
мр Новица Стевановић , дипл.инж.грађ.

Инвеститор пројекта: / Investor:
" ИНФРАСТРУКТУРА ЖЕЛЕЗНИЦЕ СРБИЈЕ " А.Д.
/ " INFRASTRUCTURE RAILWAYS OF SERBIA " JSC
Немањина 6/IV, Београд / Nemanjina Street 6/IV, Belgrade

Наручилац пројекта: / Employer: Joint Venture of
China Railway International Corporation Ltd. (CRIC)
No.10 Fuxing Road,Haidian District,Beijing
P.R China, 100844
China Communication Construction Company Ltd. (CCCC)
No.85 Deshengmenwai Street,Xicheng District,Beijing
P.R China, 100088

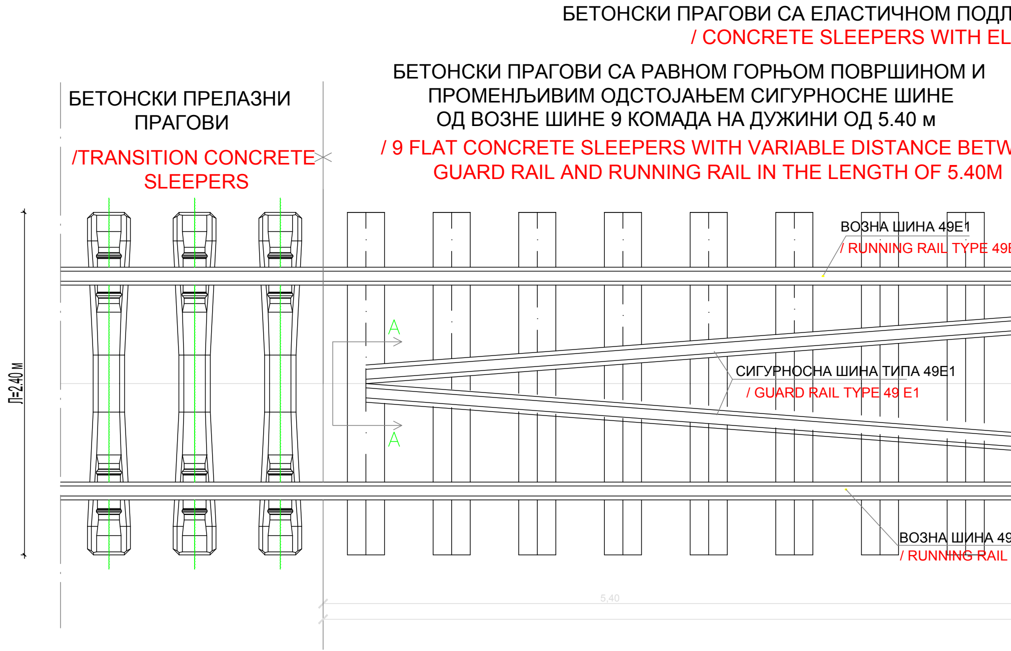
Објекат: /Structure:
ПРУГА БЕОГРАД - СУБОТИЦА - ДРЖАВНА ГРАНИЦА (КЕЛЕБИЈА)
ДЕОНИЦА ПРУГЕ НОВИ САД - СУБОТИЦА - ДРЖАВНА ГРАНИЦА (КЕЛЕБИЈА)
BELGRADE - SUBOTICA - STATE BORDER (KELEBIA) RAILWAY LINE
SECTION : NOVI SAD - SUBOTICA - STATE BORDER (KELEBIA)

Део пројекта: / Part of Design:
2/2.6.1 ПРОЈЕКАТ ГОРЊЕГ СТРОЈА ЗА МОСТОВСКЕ КОНСТРУКЦИЈЕ ДУЖИНЕ ПРЕКО 40м-ДЕОНИЦА НОВИ САД-РУМЕНКА ИЗЛАЗ
2/2.6.1 DESIGN OF SUPERSTRUCTURE FOR BRIDGE STRUCTURES LONGER THAN 40M SECTION NOVI SAD-RUMENKA ENTRY

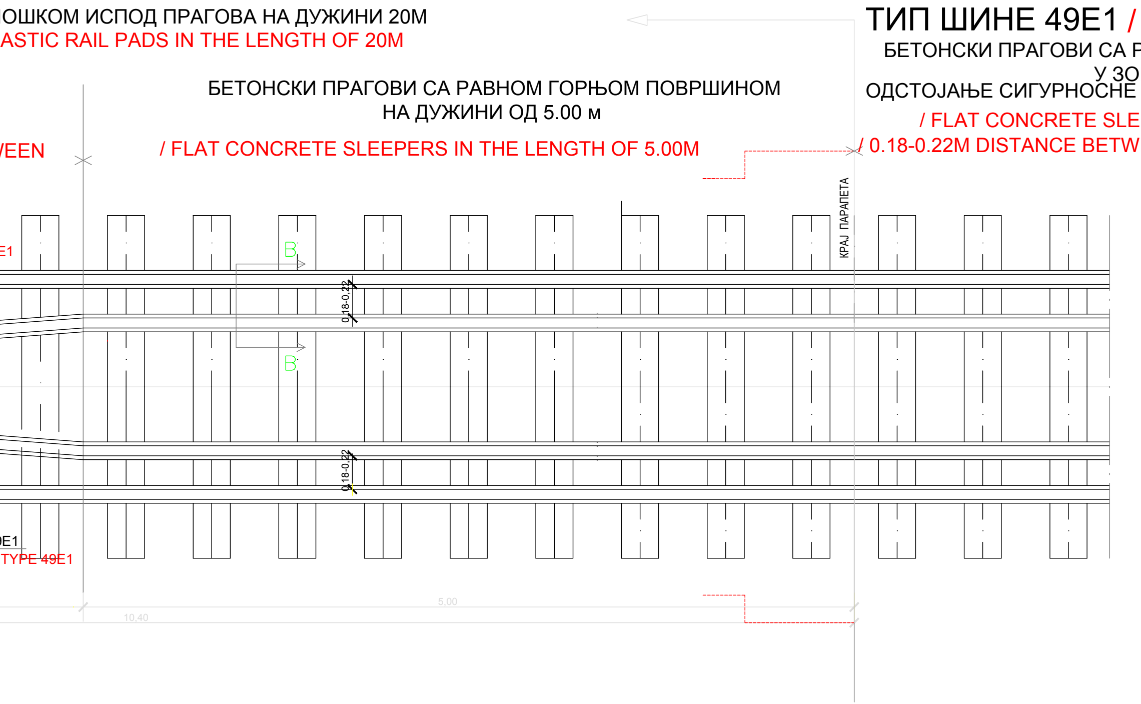
Цртеж: / Drawing:
ДИСПОЗИЦИЈА КОЛОСЕКА НА МОСТОВИМА СА СИГУРНОСНОМ ШИНОМ-ТИП ШИНЕ 60Е1
LAYOUT OF TRACKS WITH GUARD RAILS ON BRIDGES TYPE 60E1

Размера: Scale:
1:20
1:10

Врста тех.док.: Type of tech.docum.	датум: /date:	Цртеж бр. /Drawing No.:
ПЗИ / DFC	**08.2021**	2020-250-CAO-2/2-6.1.7.8


БЕТОНСКИ ПРАГОВИ СА ЕЛАСТИЧНОМ ПОДЛ
/ CONCRETE SLEEPERS WITH EL
БЕТОНСКИ ПРАГОВИ СА РАВНОМ ГОРЊОМ ПОВРШИНОМ И ПРОМЕНЉИВИМ ОДСТОЈАЊЕМ СИГУРНОСНЕ ШИНЕ ОД ВОЗНЕ ШИНЕ 9 КОМАДА НА ДУЖИНИ ОД 5.40 м
/ 9 FLAT CONCRETE SLEEPERS WITH VARIABLE DISTANCE BETW
GUARD RAIL AND RUNNING RAIL IN THE LENGTH OF 5.40M
БЕТОНСКИ ПРЕЛАЗНИ ПРАГОВИ
/TRANSITION CONCRETE SLEEPERS
ВОЗНА ШИНА 49E1
/ RUNNING RAIL TYPE 49E
A
СИГУРНОСНА ШИНА ТИПА 49E1
/ GUARD RAIL TYPE 49 E1
A
Л=2.40 м
ВОЗНА ШИНА 49
/ RUNNING RAIL
5,40

ДИСПОЗИЦИЈА КОЛОСЕКА НА МОС


ОШКОМ ИСПОД ПРАГОВА НА ДУЖИНИ 20М
ASTIC RAIL PADS IN THE LENGTH OF 20M
БЕТОНСКИ ПРАГОВИ СА РАВНОМ ГОРЊОМ ПОВРШИНОМ
НА ДУЖИНИ ОД 5.00 м
/ FLAT CONCRETE SLEEPERS IN THE LENGTH OF 5.00M
VEEN
ТИП ШИНЕ 49Е1 /
БЕТОНСКИ ПРАГОВИ СА Р
У ЗО
ОДСТОЈАЊЕ СИГУРНОСНЕ
/ FLAT CONCRETE SLE
/ 0.18-0.22M DISTANCE BETW
КРАЈ ПАРАПЕТА
E1
B
B
0,18-0,22
0,18-0,22
0E1
TYPE 49E1
5,00
10,40

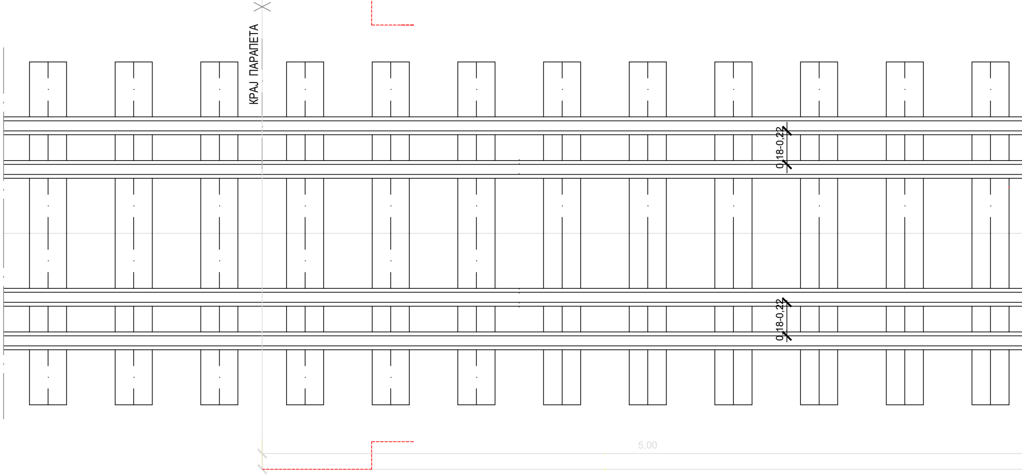
СТОВИМА СА СИГУРНОСНОМ ШИНОМ / LAYOUT OF TRACKS WITH GUAR

RAILS TYPE 49E1

РАВНОМ ГОРЊОМ ПОВРШИНОМ
НИ МОСТА
ШИНЕ ОД ВОЗНЕ ШИНЕ 0.18-0,22 м
EPERS IN THE BRIDGE AREA
EEN GUARD RAIL AND RUNNING RAIL

БЕТОНСКИ ПРАГОВИ СА ЕЛАСТИЧНОМ ПОДЛО
/ CONCRETE SLEEPERS WITH ELAST

БЕТОНСКИ ПРАГОВИ СА РАВНОМ ГОРЊОМ ПОВРШИНОМ
НА ДУЖИНИ ОД 5.00 м
/ FLAT CONCRETE SLEEPERS IN THE LENGTH OF 5.00M


КРАЈ ПАРАПЕТА
0,18-0,22
0,18-0,22
5,00

D RAILS ON BRIDGES

ШКОМ ИСПОД ПРАГОВА НА ДУЖИНИ 20М

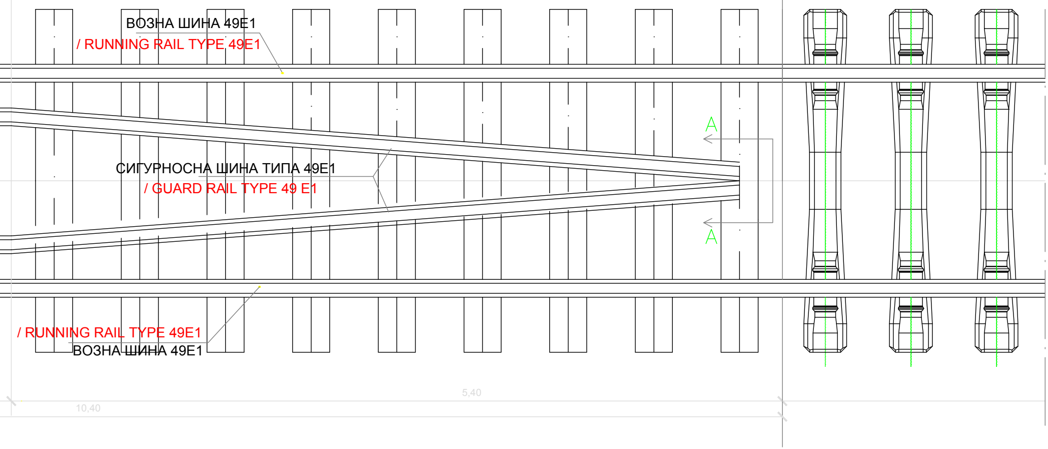
TIC RAIL PADS IN THE LENGTH OF 20M

БЕТОНСКИ ПРАГОВИ СА РАВНОМ ГОРЊОМ ПОВРШИНОМ И
ПРОМЕНЉИВИМ ОДСТОЈАЊЕМ СИГУРНОСНЕ ШИНЕ
ОД ВОЗНЕ ШИНЕ 9 КОМАДА НА ДУЖИНИ ОД 5.40 м

/ 9 FLAT CONCRETE SLEEPERS WITH VARIABLE DISTANCE BETWEEN
GUARD RAIL AND RUNNING RAIL IN THE LENGTH OF 5.40M

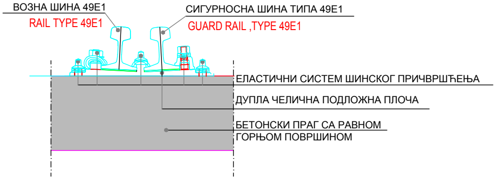
БЕТОНСКИ ПРЕЛАЗНИ
ПРАГОВИ

/TRANSITION CONCRETE
SLEEPERS

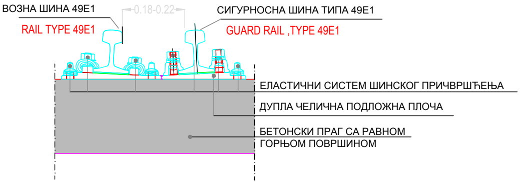


ВОЗНА ШИНА 49Е1
/ RUNNING RAIL TYPE 49E1
СИГУРНОСНА ШИНА ТИПА 49Е1
/ GUARD RAIL TYPE 49 E1
A
A
/ RUNNING RAIL TYPE 49E1
ВОЗНА ШИНА 49Е1
5,40
10,40

A-A
P=1:10


ВОЗНА ШИНА 49E1
RAIL TYPE 49E1
СИГУРНОСНА ШИНА ТИПА 49E1
GUARD RAIL ,TYPE 49E1
ЕЛАСТИЧНИ СИСТЕМ ШИНСКОГ ПРИЧВРШЋЕЊА
ДУПЛА ЧЕЛИЧНА ПОДЛОЖНА ПЛОЧА
БЕТОНСКИ ПРАГ СА РАВНОМ
ГОРЊОМ ПОВРШИНОМ

B-B
P=1:10


ВОЗНА ШИНА 49E1
0.18-0.22
RAIL TYPE 49E1
СИГУРНОСНА ШИНА ТИПА 49E1
GUARD RAIL ,TYPE 49E1
ЕЛАСТИЧНИ СИСТЕМ ШИНСКОГ ПРИЧВРШЋЕЊА
ДУПЛА ЧЕЛИЧНА ПОДЛОЖНА ПЛОЧА
БЕТОНСКИ ПРАГ СА РАВНОМ
ГОРЊОМ ПОВРШИНОМ

03		
02		
01		
Број/Number	Датум / Date	Опис / Description

Ревизиони блок: / Revision block:

САОБРАЋАЈНИ ИНСТИТУТ ЦИП, д.о.о.
INSTITUTE OF TRANSPORTATION CIP ltd
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Одговорни пројектант :
Responsible designer:
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лиценца број:/ license No.: 315 1404 03

Сарадници: / Associates:

Унутрашња контрола: / Internal control:
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Главни пројектант: / Chief designer:
Др Љиљана Милић Марковић,дипл.грађ.инж.

Руководилац организационе јединице:
Manager of organization unit:
мр Новица Стевановић , дипл.инж.грађ.

Инвеститор пројекта: / Investor:
" ИНФРАСТРУКТУРА ЖЕЛЕЗНИЦЕ СРБИЈЕ " А.Д.
/ " INFRASTRUCTURE RAILWAYS OF SERBIA " JSC
Немањина 6/IV, Београд / Nemanjina Street 6/IV, Belgrade

Наручилац пројекта: / Employer: Joint Venture of
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China Communication Construction Company Ltd. (CCCC)
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P.R China, 100088

Објекат: /Structure:
ПРУГА БЕОГРАД - СУБОТИЦА - ДРЖАВНА ГРАНИЦА (КЕЛЕБИЈА)
ДЕОНИЦА ПРУГЕ НОВИ САД - СУБОТИЦА - ДРЖАВНА ГРАНИЦА (КЕЛЕБИЈА)

BELGRADE - SUBOTICA - STATE BORDER (KELEBIA) RAILWAY LINE
SECTION : NOVI SAD - SUBOTICA - STATE BORDER (KELEBIA)

Део пројекта: / Part of Design:
2/2.6.1 ПРОЈЕКАТ ГОРЊЕГ СТРОЈА ЗА МОСТОВСКЕ КОНСТРУКЦИЈЕ ДУЖИНЕ ПРЕКО 40м-ДЕОНИЦА НОВИ САД-РУМЕНКА ИЗЛАЗ

2/2.6.1 DESIGN OF SUPERSTRUCTURE FOR BRIDGE STRUCTURES LONGER THAN 40M SECTION NOVI SAD-RUMENKA ENTRY

Цртеж: / Drawing:
ДИСПОЗИЦИЈА КОЛОСЕКА НА МОСТОВИМА
СА СИГУРНОСНОМ ШИНОМ-ТИП ШИНЕ 49E1
LAYOUT OF TRACKS WITH GUARD RAILS ON BRIDGES TYPE 49E1

Размера:
Scale:
1:20
1:10

Врста тех.док.: Type of tech.docum.:	датум:/date:	Цртеж бр./Drawing No.:
ПЗИ / DFC	**08.2021**	2020-250-CAO-2/2-6.1.7.9